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THE PARSONS STEAM TURBINE ON GERMAN WARSHIPS.*

By Dr. Alfred Gradenwitz.

While the British navy was the first to realize the advantages that might be derived from the use of steam turbines for the propulsion of ships, the German naval authorities have not been slow to follow the English example. The recent construction of two turbine-driven vessels, the small cruiser "Lübeck" (10,000 horse-power and 22 knots) and the torpedo boat "S.125" (6,300 horse-power and 27 knots) has given a powerful impulse to the use of marine turbines, which no doubt will soon be adopted to some large extent also on German merchant ships. It may be mentioned that both of the vessels referred to have been equipped with Parsons turbines, and some particulars of the special arrangement chosen will be given in the following.

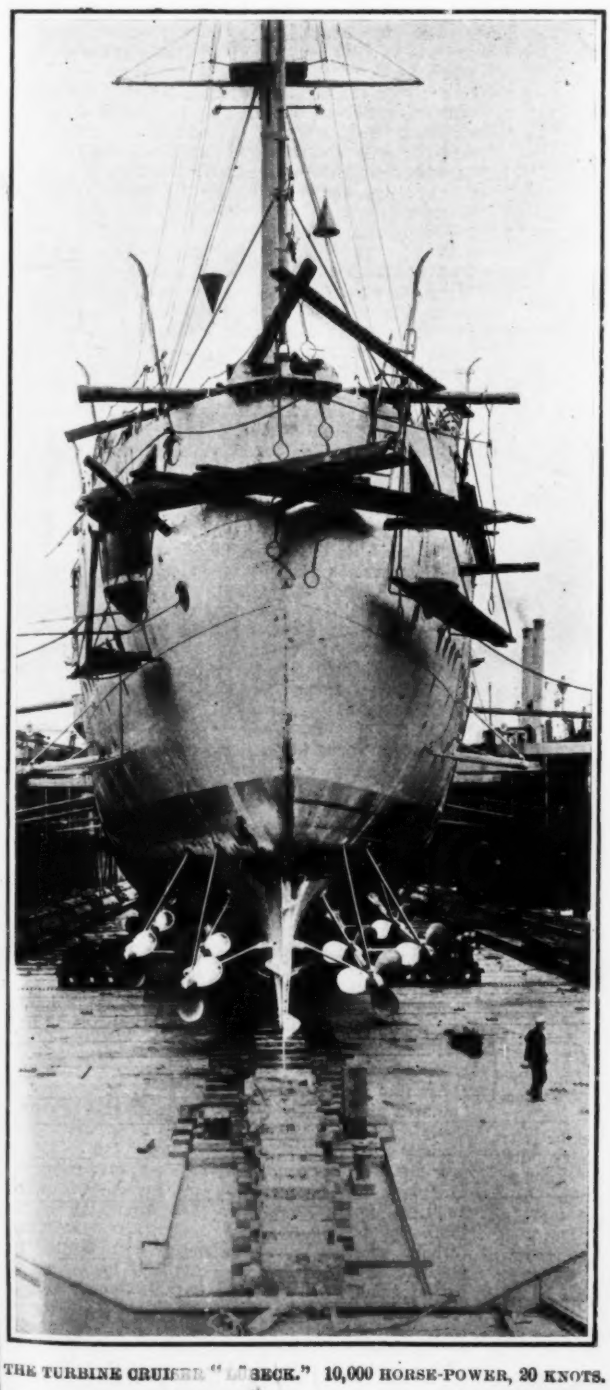
It should be understood at the very outset that the design, as usual on merchant ships, will not prove available for warships and yachts, where an economical operation of the turbine plant is required within a large range of speeds (including low and medium speeds, 12 to 17 knots). In order to make up in slow sailing for the reduction in the number of revolutions, which is known to have a great bearing on the economy of turbines, and to secure satisfactory working even with reduced amounts of steam, one or two additional turbine cylinders, called "cruising turbines," are inserted in series. By this arrangement the economical advantages of reciprocating steam engines are obtained in the case of slow sailing without losing the good points characteristic of turbines as compared with reciprocating steam engines in the case of maximum outputs.

As soon as the speed exceeds a given limit, the "cruising" turbines are thrown out, and the live steam supplied to the high-pressure turbines immediately, when the cruising turbines running without load in the vacuum are connected with the condenser by a special conduit. It should be mentioned that in backing, all turbines, except the turbines which receive a full charge of live steam, run without load in the vacuum.

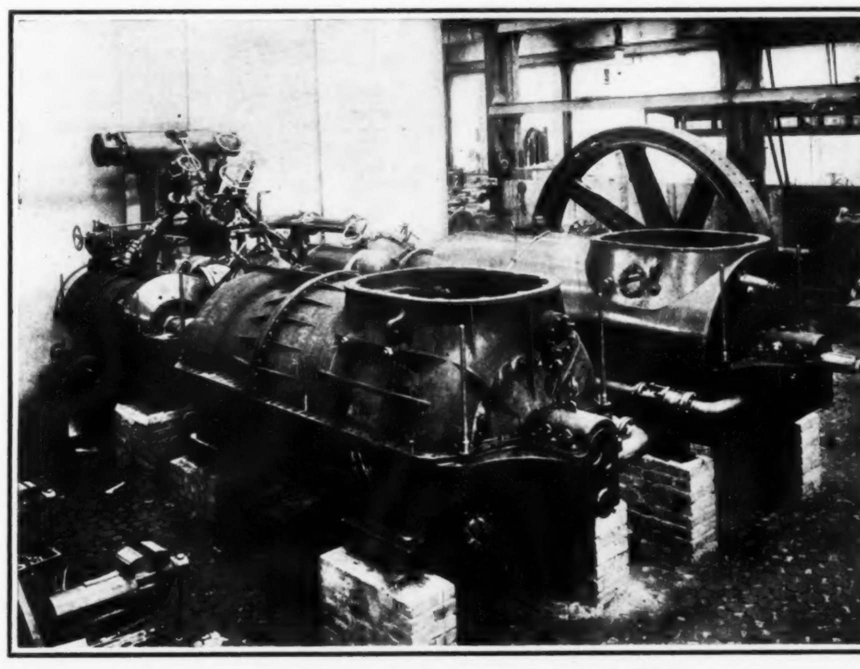
The "cruising" turbines show, as a rule, the distinctive feature from the main turbines that they are constructed as perfectly self-contained units, the thrust on the vane being dealt with in the turbine itself. As they are operated only temporarily, the stuffing boxes are provided with two channels, into one of which live steam penetrates, so as to obtain a tightening effect against atmospheric air should the cruising turbine run at no load in the vacuum. From the second channel steam is derived and supplied to the stuffing boxes of a cylinder worked by steam at atmospheric pressure, during the time the cruising turbine is operating.

The thrust bearings of the cruising turbines are mainly intended for dealing with small differences in pressure, and for maintaining the running wheel in an axial position. They are generally connected with the low-pressure turbine by a clutch, which is movable longitudinally, and which in the case of a permanent maximum output of the plant can be loosened, thus disconnecting entirely the cruising turbines. The latter can be arranged also in two separate sets, with a view either to allow of a longitudinal or transverse

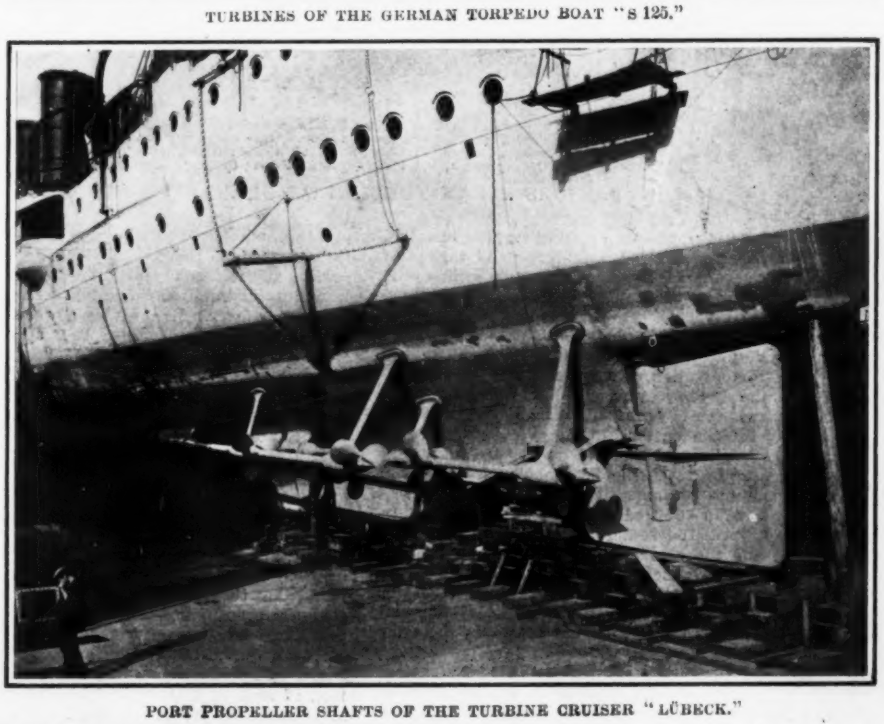
* Specially prepared for the Scientific American Supplement.



THE TURBINE CRUISER "LÜBECK." 10,000 HORSE-POWER, 20 KNOTS.



TURBINES OF THE GERMAN TORPEDO BOAT "S 125."



PORT PROPELLER SHAFTS OF THE TURBINE CRUISER "LÜBECK."

THE PARSONS STEAM TURBINE ON GERMAN WARSHIPS.

bulkhead being arranged, or of obtaining a four-shaft arrangement, two for each set. Such self-contained sets, working independently of each other, will consist each of one high-pressure turbine and one low-pressure turbine, in addition to one or two high-pressure reversing turbines. The number of the latter mainly depends on the duty required in the case of backward running. In the case of warships, a cruising turbine is added to each of the turbine sets. The two marching turbines can be connected in series, discontinuing the independence of the two sets, with a view to insuring an economical operation in the case of small speeds. In case a longitudinal bulkhead is arranged, the latter is traversed by the connecting conduit of the marching turbine when bulkhead slides are used.

Each set comprises a complete condensing plant, which is able if required to work on the opposite side through a connecting conduit liable to be locked. According to the number of main turbines, the vessel has four shafts. The question as to the use of either one or two propellers is mainly dependent on technical requirements.

The working of a turbine plant including cruising turbine is as follows:

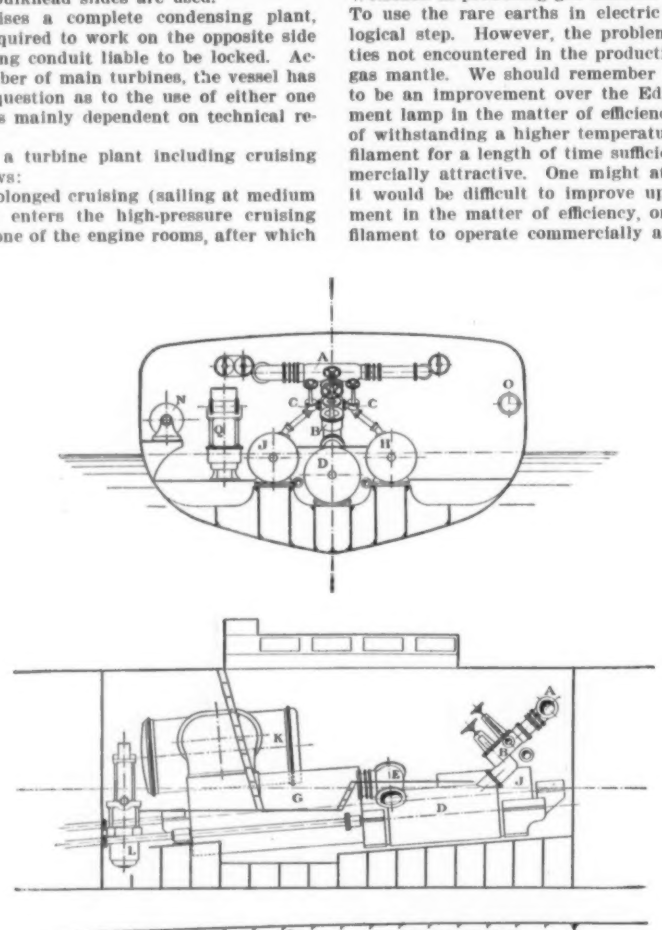
In the case of prolonged cruising (sailing at medium speeds) the steam enters the high-pressure cruising turbine located in one of the engine rooms, after which it traverses the low-pressure cruising turbine installed in the other engine room, distributing itself thence to the high-pressure main turbines of the two engine sets, whence it flows to the condensers through the low-pressure main turbines.

When the speed exceeds about 19 knots per hour, and up to maximum speeds, the cruising turbines are thrown out of operation, when the steam entering immediately the high-pressure steam turbines on both sides, traverses the low-pressure turbines, whence it is led off into the condensers.

In the case of a four-shaft passenger steamer, only the latter alternative should be considered, as such a steamer sailing permanently at maximum speeds would not have to be fitted with cruising turbines. In sailing backward, the steam to the forward turbines is cut off, and the steam admission to the reversing turbines opened, whence it is exhausted immediately into the condenser.

The installation of Parsons turbines does not call for any departures from the usual design of the after part of the vessel.

It may be mentioned that whenever the construction of the vessel requires the installation of two or more sets of Parsons turbines in series, that is, with a view to allow for some large lateral coal bunkers, this arrangement will prove quite practicable.



A, steam sieve; B, main valve; C, cut-off valves; D, high-pressure main turbine; E, reaction valves; F, reaction valve; G, low-pressure main turbine; H, high-pressure cruising turbine; J, low-pressure cruising turbine; K, condensers; L, air pumps; M, circulating pumps; N, turbo-dynamo; O, evaporators; P, drinking-water condenser; Q, main feed pump.

THE PARSONS STEAM TURBINE ON GERMAN WARSHIPS.

THE USE OF RARE EARTHS IN ELECTRIC ILLUMINANTS.*

By MURRAY C. BEEBE.

As scientists and engineers have come to a realization of the inefficiency of existing methods of illumination, the problem of improving upon these inefficient methods has received considerable attention. While the element carbon has, heretofore, been almost exclusively used commercially in both arc and incandescent lamps, the rare earth oxides, so called, have recently been found to possess desirable properties for use as illuminants.

We are already familiar with the work of Auer von Welsbach in producing gas mantles of thoria and ceria. To use the rare earths in electric illuminants was a logical step. However, the problem possessed difficulties not encountered in the production of a serviceable gas mantle. We should remember that an illuminant, to be an improvement over the Edison or carbon filament lamp in the matter of efficiency, must be capable of withstanding a higher temperature than the carbon filament for a length of time sufficient to make it commercially attractive. One might at first suppose that it would be difficult to improve upon the carbon filament in the matter of efficiency, or the ability of the filament to operate commercially at a very high temperature, since carbon is practically infusible, and the rare earths are fusible. Carbon, however, slowly vaporizes at the temperature at which it operates in the incandescent lamp, and finally, after 400 to 600 hours, has depreciated in light-giving power to such an extent that it is best to replace it. It is the vaporizing properties rather than the melting points of the materials, with which we are concerned in this problem. It has long been known that substances which are commonly regarded as insulators, such as glass and porcelain, become quite good conductors of electricity at higher temperatures.

Prof. Buff, in 1854, read a paper "On the Conductivity of Heated Glass for Electricity," and "Faraday's Researches," gives a number of examples of such conductors. Jablochkoff attempted to use refractory materials, such as lime, to separate and insulate the carbon electrodes of his Jablochkoff candle. He soon found that these supposed insulators in reality became conductors and emitted light by virtue of the current passing through them from one electrode to another. He even designed terminals with which to carry the current of electricity to the lime conductor, with the idea of making a lamp based on this principle. It is safe to say that were it possible to produce electricity as cheaply then as now lamps of the Nernst type would have been known commercially much sooner than they were, for Jablochkoff's persistent attempts at commercial exploitation were baffled largely by the undeveloped state of electrical engineering.

That the rare earth oxides are exceedingly refractory and do not readily vaporize at high temperatures makes the Welsbach mantle possible; that these oxides will conduct electricity when hot makes the Nernst lamp possible. Of all the oxides which conduct electricity but few are refractory enough for an efficient filament or glower. It was in determining the most desirable of these and in fixing the best proportions to use that Nernst did his greatest work.

Ordinary red iron oxide, when formed into filaments and baked, will conduct electricity at ordinary temperatures, but such filaments do not withstand sufficiently high temperatures to be used as light sources. Magnesia and thoria, on the other hand, withstand exceedingly high temperatures, but these conduct electricity only with great difficulty. In general, mixtures of two or more oxides conduct better than a single oxide, and, in turn, the fusing point of the mixture is lower than that of either oxide alone. It seems that the vaporizing point is not necessarily lowered, judging from the fact that thoria and the small amount of ceria used in a Welsbach mantle form quite a stable mixture, or possibly a chemical combination, while ceria alone or uncombined is a somewhat undesirable oxide from its rather marked tendency to vaporize.

It would be a long story to take up the various properties of all the rare earth oxides and the possible combinations with one or more of the others. A mixture which is used largely in lamps of the Nernst type is composed of eighty-five per cent zirconium oxide to fifteen per cent of yttria earths. Zirconium is not properly classified among the rare earths, though it is customary to do so. The term "yttria," as used here, means in reality a mixture of many oxides occurring together in certain minerals and closely allied in physical and chemical properties. Zirconia was used in comparatively large quantities for the first Welsbach mantles, and hence, considerable attention had been given to various methods of producing it for such use. While many of the experimental glowers were made from zirconia bought from chemical supply houses, it was impossible to obtain uniform results from such material. Good zircon ore, which is a zirconium silicate, occurs in abundance in Henderson County, North Carolina, and this ore contains about sixty-seven per cent of zirconium as oxide. By treating this ore in the following manner, quite uniform results are possible.

The ore is ground very fine in a ball mill and mixed with twice its weight of crude acid potassium fluoride. This is placed in an ordinary graphite crucible and heated slowly until thoroughly fused, and the ore is completely dissolved. The fused mass is then ground and dissolved in hot water containing a quantity of crude hydrofluoric acid equal to about one-tenth the weight of the fused mass. The silica remains undissolved as potassium silicofluoride (K_2SiFl_6) and the potassium zirconium fluoride (K_2ZrFl_6) is drained off while boiling hot into a silver-lined vessel. Upon cooling, the filtrate develops crystals of potassium zirconium fluoride, and, doubtless, small quantities of other elements in similar crystal form. Iron and many other impurities which are present in the ore, or have been introduced by the use of crude reagents, remain in the liquor which is drained from the crystals. The crystallizing process may be much hastened by artificial cooling. Rinsing the crystals with cold water is likewise beneficial in removing all traces of the mother liquor. The crystals are gathered and fused in a platinum dish. By this means, any silica present seems to be vaporized off, and other impurities, like titanium, are made insoluble. The fused mass is ground and dissolved in hot water and crystallized as before. A few of the first crystals are removed; or, instead, alcohol may be added to the solution until a small amount of crystalline precipitate is formed. These first crystals contain much of the undesirable impurities. They are, therefore, removed and the crystallizing process is continued. The pure crystals are then dissolved in hot water and the solution is made rather acid by the addition of pure hydrofluoric acid. Ammonia is now carefully added to the hot solution until a small amount of precipitate is formed. If the solution of crystals has been made acid, the addition of ammonia, even until alkaline, will precipitate out iron and some other foreign metals but will leave the zirconia in solution until it is cooled and diluted.

This method was found to be an exceedingly simple one for removing iron from zirconia, which, by other methods, is a troublesome operation. The hot filtrate after removing the precipitate of iron, is dropped directly into a cold ammonia solution which at once precipitates zirconia as a hydrate. Up to this stage of the process, it has been necessary to use vessels and utensils not affected by hydrofluoric acid. The last precipitate may be made in glass or wooden receptacles. The precipitate is washed several times by decantation and then pressed out on suction filters, and after thorough drying by heat is powdered and sifted through fine bolting cloth, and is then ignited in a platinum dish, over a very gradually increasing temperature and with constant stirring. The ignition process requires several hours, or sometimes days, the final temperature being a good red heat. Traces of silica are removed by this operation.

The physical condition of the precipitate is dependent to a great extent upon the amount of hydrofluoric acid in excess. When precipitated from an almost neutral

* Paper read at a meeting of the chemical section of the Engineers' Society of Western Pennsylvania, March 23, 1905.

solution, the precipitate dries into hard pieces translucent in appearance, and which are difficult to pulverize. With the greater excess of acid, the material dries in lumps resembling starch, in which condition it is much more suited to our purpose.

The zirconium made by this process seems to be reasonably pure. Precautions must be taken to keep out dirt, and to that end it has been found advantageous to purify the air admitted to the rooms where the glower materials are prepared by passing it through a water spray. An absolutely pure zirconia is not required and though a trace of silica improves the efficiency and seems to diminish the initial depreciation of candle-power of a glower, it is a dangerous element to have present, for slightly more than a trace will cause a rapid change in potential difference at the glower terminals besides causing lack of uniformity in the behavior of glowers of one batch, due to the fact that the silica becomes unevenly distributed among the glowers by vaporization and condensation occurring in a roasting process, which will be described later.

Although the purest materials make the best glowers for direct current, it can not be said that an absolutely pure zirconia is desirable for alternating-current glowers. Silica is particularly undesirable in direct-current glowers. In general, a glower which operates well on direct-current, showing almost no change in potential difference, will show a greater change when operated upon an alternating-current circuit.

The purity of the zirconia may be controlled, to some extent, by the number of times the material is crystallized during the purifying process, though each operation is attended with some loss of material. Physical properties are quite as important as chemical properties and the procedure above described was evolved to give proper physical, as well as chemical, properties to the material.

After all, "handsome is as handsome does"—and the real test for the glower material lies in its ability to make good glowers. Test glowers have been made from hundreds of lots of zirconia and these tests, together with careful chemical records of each lot, have been the guide in developing the chemical process necessary for the production of good glowers. For direct-current glowers, a crystallizing process is also considerably used, but from a solution of zirconia in hot dilute hydrochloric acid. After two or three such crystallizations, it is necessary to precipitate from a hydrofluoric acid solution, as in the first process, to get the material into proper physical shape.

As to the yttria used, this is principally obtained from the minerals gadolinite or yttrialite. Gadolinite is found in Norway and Sweden, and also in Llano County, Texas. The Texas deposit seems to be confined to a very small district and there is every evidence that it is a result of a volcanic eruption. It is found in crystalline form associated with yttrialite, crytolite, fergusonite, rowlandite, allanite and other minerals. The ores from the Llano County district are radio-active and the presence of a pocket in the quartz is generally indicated by bluish discolorations radiating from the pocket through some distance of the surrounding quartz. It is also claimed that the ores contain small quantities of confined helium gas. Gadolinite contains, roughly, 42 to 45 per cent of yttria earths, 23 per cent of silica, 13 per cent iron as oxide, and 9 to 12 per cent of beryllia. Yttrialite contains 43 to 47 per cent yttria earths, 30 per cent silica, 5 to 6 per cent ceria, didymia, and lanthan, as well as small percentages of urania. Fergusonite contains 32 to 42 per cent yttria earths, 32 to 46 per cent niobia. Rowlandite contains 47 to 62 per cent yttria earths, 26 per cent silica and small percentages of iron and magnesia. Allanite contains 26 per cent ceria and didymia, with a small percentage of yttria earths and considerable percentages of iron, calcia, and alumina.

It is a comparatively simple matter to obtain and purify the yttria earths from gadolinite and yttrialite so that they are suitable for glower making. About one thousand grammes of ground ore are dissolved in crude aqua regia. The residue is filtered off and the solution evaporated to dryness, repeating this operation several times, or until all silica is removed. The neutral solution is then diluted to several liters and the addition of a hot solution of oxalic acid to the hot solution containing the earths, brings down the rare earths as oxalates, leaving iron and other impurities in solution. The oxalate is washed thoroughly with hot water and ignited, and the crude yttria earths are dissolved in dilute hydrochloric acid, just sufficient in amount to dissolve the oxide. To the rather dilute and neutral solution, which is cold, crystals of potassium sulphate are added in excess. After standing twenty-four hours, the cerium group has been quite thoroughly separated as double sulphates and the filtrate is then treated with ammonia to bring down the hydrates of the rare earths, thus freeing them of the great excess of potassium sulphate. The washed precipitate is dissolved in a quantity of pure hydrochloric acid just sufficient to dissolve it, and again treated with boiling oxalic acid solution, as before. This brings down the rare earth oxalates in sufficiently pure form. The oxalates are thoroughly washed with hot water and ignited, and any remaining potassium is separated from the ignited oxides by washing upon a filter with hot water.

With the yttria, as well as the zirconia, physical properties are important; and the oxalate method gives an exceedingly fine precipitate which requires no mechanical treatment.

Experiments indicate that the yttria earths of the greatest atomic weights give the most satisfactory results in glowers. In other words, ytterbia is better than yttria. Owing, however, to the great difficulty of separating the yttria earths from each other, which is so far possible only by laborious fractionation processes, entailing great losses, not much has been done toward using the higher atomic weight yttria earths beyond selecting ores which are rich in these earths.

The Llano County ores seem to be superior to the foreign ores in this respect, the atomic weights being

Yttrialite	115
Rowlandite	107
Fergusonite	103
Gadolinite	100

while the foreign ores may be as low as 90 or 92.

The zirconia and yttria earths mixed in the proportions given above, namely, about eighty-five and fifteen, or ninety and ten, and about five per cent of starch or gum tragacanth, are thoroughly mixed and kneaded into a hard dough and squirted by pressure through a die of proper size. This string, as it may be called, is dried and then broken into suitable lengths which are roasted to an intense white heat in a platinum box. The pieces are then ready to have terminals placed upon them.

A Nernst terminal is made by winding stranded platinum wire about the end of the stick of material and then pasting over with a paste composed of ground glowers and zirconium chloride, thus forming a hard cement.

The Hanks terminal has the platinum embedded in the glower material, the operation being carried on by the aid of an electric arc in which the glower material is fused.

Certain it is that the mode of conducting the current is electrolytic in character. The specific resistance varies with the relative proportions of the constituents. In order to obtain glowers of the same specific resistance, when using yttria earths of high atomic weights, as when low atomic earths are used, it is necessary to have the presence of the higher atomic weight materials in proportion to the atomic weights.

Upon direct-current circuits, the positive end of a glower generally runs much hotter than the negative end, and a black discoloration appears at the negative end, especially if impurities are present. In fact, this is one of the most certain indications of the presence of an impurity.

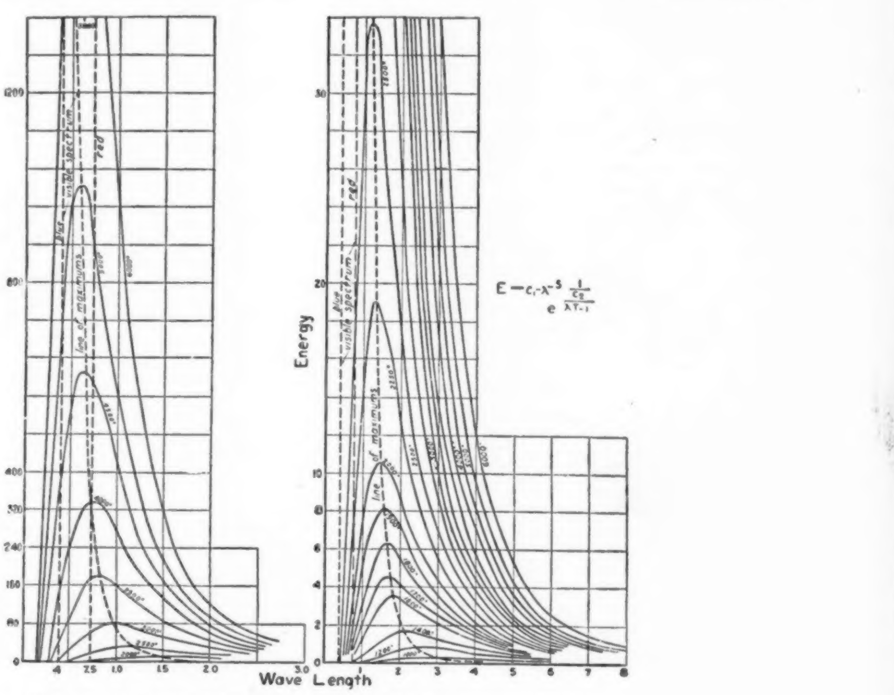
A glower operated in vacuum soon destroys the vacuum, probably due to oxygen gas liberated by electrolytic action. That all the current is carried by electrolytic means seems incredible, for the current carried per square unit of cross-section is far greater than can easily be accounted for by our usual conceptions of electrolytic laws. For example—upon direct current and calculated by electro-chemical equivalents, the entire glower would be decomposed into the constituent elements in a very few minutes. Doubtless electrolytic decomposition and recombination do take place, but is it possible to account for the entire transport of current in this way? The assumption that the current is all so carried seems unnecessary in view of what is known of the power of highly incandescent bodies to ionize air to render it conducting. The air in the neighborhood of a glower is conducting, and to such an extent that the leakage current from glower to heater had to be reckoned with early in the experimental work, and the difficulty was obviated by the use of a double-pole cutout which disconnected the heaters completely from electrical connection with the remainder of the lamp after the glower started.

In connection with these speculations as to the real nature of the process by which the current traverses the glower, it is a fact that glowers which have operated for even a short time upon direct current will, when the current strength is diminished sufficiently to maintain the glower at only a good red heat, explode with considerable violence. This may be accounted for by considering that the conductivity at low temperature is insufficient to ionize the surrounding and contained gases. The means of conducting the current then being largely electrolytic in character, the combination of the products of electrolytic decomposition can not so readily take place, since the ions can not so readily traverse the length of the glower to combine at the lower temperature; consequently disruption occurs.

The suggestion that has so often been made, namely, that the current be reversed in direction at intervals, as, for instance, every time the lamp is started, is altogether impracticable for the reason that a glower once operated upon direct current must never have its poles reversed, for a reversal means almost instant disruption. The potential difference across the terminals of the glower immediately after such a reversal is lower, indicating something analogous to polarization effects as we know them in aqueous electrolytes.

In general, with the Nernst terminal, the potential difference across the glower at the normal current value is the same with alternating or direct current. With the Hanks terminal, or embedded type, the potential difference with direct current may be as much as twenty volts lower. The Hanks terminal will operate on direct current, but not satisfactorily as a commercial proposition. The life of the alternating-current glowers is greater upon high frequencies than upon low frequencies, again suggesting electrolytic conductivity, at least in part.

The small glowers, up to 0.5 ampere, are made solid in cross section; the largest ones are generally made tubular; and in fact, one-ampere glowers must be made so. The reason for this is not that greater efficiency is sought by increasing the ratio of surface to volume, which is, of course, a fallacy, but inasmuch as the glower possesses a decided negative temperature coefficient as regards electrical conductivity, the center of a large glower would become molten before the outside surface reached an efficient temperature, the center being the better conductor. Glowers which have been greatly overrun, often exhibit this truth by the appearance of a nodule of molten material which has spurted out to the surface.



RELATION BETWEEN TEMPERATURE AND ENERGY RADIATED ON VARIOUS WAVE-LENGTHS.

GLOWER IN VACUUM.

A glower will operate in vacuum but the vacuum rapidly deteriorates, as before stated. A blue aurora or luminous haze surrounds the glower thus operated, either with direct or alternating current, and has been thought to be due in some way to vaporized metal (zirconium or yttrium) recombining with the slight amount of oxygen liberated. This idea seems plausible from the facts that objects such as wire or glass near the glower become coated with a white deposit of the glower oxides in a comparatively short time.

It would seem that oxygen necessarily plays a part in conducting the current, for a glower in an atmosphere of hydrogen or nitrogen behaves similarly to the one operated in a vacuum. In carbon monoxide or dioxide the glower exhibits the same characteristics as in air. The glower operated in vacuum exhibits a peculiar sluggishness in responding to changes in voltage at its terminals.

A commercial glower must operate at a high temperature to be efficient. Nernst glowers operate at about 2,300 degrees Centigrade, it is supposed from determinations made by photometric means, and at about twice the efficiency of a carbon incandescent lamp. The spectrum of a glower is a continuous one and no evidences of selective emission in any particular re-

gion are noted. During the life of a glower, which averages about 800 hours under normal conditions of manufacture and voltage regulation, a depreciation of candle-power takes place due to a number of causes. In the first place, all oxides of the rare earths do depreciate rather rapidly in light intensity per unit of surface at any given temperature. This is true even when heated by gas or electricity, and a platinum plate coated on one side with rare earths and heated from the rear by an oxy-hydrogen flame behaves similarly. It is an inherent property of these oxides and a depreciation of ten or twenty per cent may occur during the first hour. There is then a slow diminution of intensity of light, also inherent, and seemingly accompanying the tendency of the glower to change from an amorphous to a crystalline structure. A rise of potential difference across the glower terminals is usual, though it is possible to counteract this tendency, at least in part. The effect of a rise in potential difference, obviously, is to diminish the intensity of light by permitting less current to traverse the glower, running on a constant potential circuit.

With carbon incandescent lamps, the useful life or smashing point is considered to be that number of lamp-hours during which the candle-power decreases twenty per cent from the initial candle-power. Nernst lamps are similarly rated, counting as initial candle-power that measured after the initial decrease above mentioned.

Other causes of depreciation in candle-power are blackening of the inclosing glassware and reflecting surfaces. In this connection, the blackening is due largely to platinum which has been vaporized and deposited upon these surfaces. It has been found that the purest platinum is far better than that containing iridium or other of the platinum group, since pure platinum vaporizes much more slowly than alloys with these other metals.

It is to produce uniform chemicals and glowers in which the tendency to depreciate in light intensity and increase in potental difference shall be a minimum that makes the problem so intricate and so fascinating and still capable of much improvement.

Curiously enough, not the least of the problems to be solved in the development of the Nernst lamp was to overcome the tendency of porcelains to conduct electricity, the very property which in the case of the rare earths made such a lamp as the Nernst possible. A heater is necessary to start the glower. The heater is made by winding fine platinum wire upon a porcelain tube. It was necessary to produce a suitable porcelain which would withstand the high temperature necessary, and at the same time not conduct electricity. A porcelain composed of kaolin, alumina, and silica is sufficiently refractory and porous to withstand the heat, and is an almost perfect non-conductor at high temperatures. The porcelain piece upon which the glowers and heaters are mounted is also of the same composition.

Another form of heater used more abroad than in this country is helical in shape and the glower is mounted in its axis. This is made of pure kaolin and after squirting into tubes about a millimeter in diameter and winding with fine platinum wire and covering over the wire with a paste, the small tube is bent into a helix upon a mandrel, a pointed blow-pipe flame playing upon the kaolin tube at the point where it bends onto the mandrel.

POSSIBILITIES OF SELF-STARTING FILAMENTS.

Many oxides will conduct at room temperature. A mixture of iron and tin oxides, about seventy iron to thirty tin, will start without preliminary heating and withstands rather a high temperature. There are many other similar combinations, likewise other possibilities exist, such as carbides, silicides, and borides, operated either in vacuum or gases.

A Nernst glower may be made to conduct current at low temperatures by running it for a short time in a rarefied atmosphere containing a carbon gas. If to a globe in which a glower is operating in a good vacuum, an amount of hydro-carbon gas is admitted sufficient to lower the vacuum even less than a millimeter, the potential difference across the terminals of the glower will decrease rather rapidly and in the space of a few minutes, or even seconds, the glower will have become a conductor when cold; or, in other words, self-starting.

The following experiment was tried:

A glower was mounted in a glass bulb and in the axis of a carbon filament of a helical shape. The bulb was exhausted well and sealed off. The carbon filament was used four or five times to start the glower, alternating current being employed. After the glower had run a few hours, it was noted that it was changing color at its terminals. The discoloration gradually crept toward the center and after about twenty-four hours the glower could then be started without preliminary heating. Apparently enough of the carbon filament was oxidized during the short time it was in use to give a slight quantity of free carbon monoxide in the bulb, the source of oxygen being the glower itself.

It is uncertain whether this gas was effective in reducing some of the glower material to its metallic form, or whether a conducting carbide was formed by the action of the carbon gas upon the glower materials. The former explanation seems preferable for the reason that it is noticed that the darkened portion at the negative end of direct-current glowers is of higher conductivity than the glower proper, and it seems quite likely that this deposit is a metal separated out by electrolytic action. Metallic zirconium, for example, withstands very high temperatures in the open air without oxidizing and its melting and vaporizing points where air is excluded must be very high.

Many possibilities exist, such as are suggested by the above experiments, and many of them have been tried. Boron carbide, for example, withstands very high temperatures and is a conductor while cold, though it seems to vaporize somewhat too rapidly; at least this was the case with samples tried which probably were not very pure.

A Nernst glower, as well as those composed of thoria, magnesia and almost any of the refractory oxides, may be made conducting by treatment with a hydro-carbon gas. Sodium and potassium vapor also effect a reduction to the self-starting condition, though not generally so readily as carbon.

There is a broad field still open and much that is not known of the properties of the rare metals. Oftener than not the supposedly pure metal is very impure, and the properties generally ascribed to it are in reality those of its carbide or other little known combination. Note the difference in properties of pure iron and iron containing even less than one per cent of carbon. Is it not a fact that almost nothing is known of the physical properties of the rare metals? A good example of this point, and one bearing directly on our subject, is the recently developed tantalum lamp, the filament of which is a fine thread of tantalum metal. Tantalum metal until recently was not known to possess properties which now make it a promising addition to electric illuminants.

More or less experimental work has been done, particularly in Europe, in using the rare earths in electric arcs with the idea of obtaining better efficiency and more pleasing light. Lamps have even been tried with electrodes composed entirely of the rare earth oxides, though at the present time the greatest advances in arc lighting are being made along the lines of introducing such elements as boron and tantalum into the electrodes.

In conclusion, attention is directed to a curve which has been plotted to show the relation between the temperature and the energy radiated in the various wave-lengths of light for incandescent bodies. We are apparently at the present time just on the border of the possibilities.

STEREOSCOPIC PROJECTIONS.

THE methods which have been proposed for obtaining the effect of stereoscopic relief in pictures projected on a screen may be grouped in two classes.

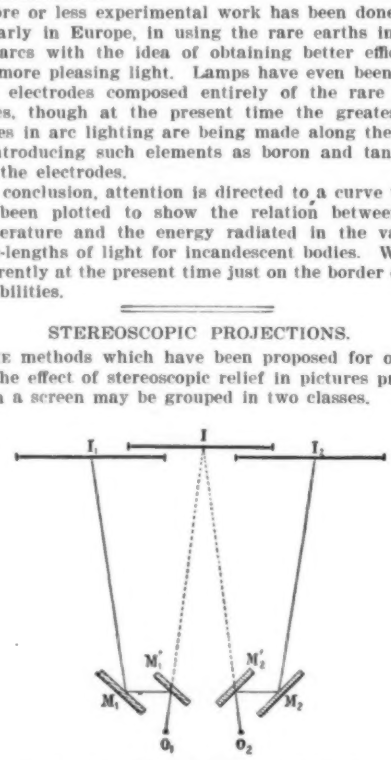


FIG. 1.—DIAGRAM OF RICHARD'S APPARATUS WITH TWO PAIRS OF MIRRORS.

In the first, the pictures intended to be viewed by the right and left eyes, respectively, are projected on the screen side by side, and simultaneously, so that they differ from ordinary stereoscopic prints only in size and distance from the observer.

In the second, the pictures are projected on the screen so that each of them occupies its entire surface. But, as they are not identical, they are superposed only generally, but not in detail, and the impression of relief is obtained by separating the confused image into its two components, and conveying each of them to the eye for which it is destined.

First method: Separate projections.—Each spectator is provided with a reflecting or refracting stereoscope adapted to the size and distance of the pictures on the screen. Fig. 1 shows how the two screen pictures, I_1 and I_2, may be reflected to the eyes of the spectator, O_1 and O_2, by two pairs of plain mirrors, so as to combine and form a single relief picture, I. The apparatus resembles the old reflecting stereoscope of Helmholtz, and Cazes's device for the direct examination of large stereoscopic prints. A screw regulates the inclination of the mirrors and, consequently, the displacement of the images, in accordance with their size and distance. This apparatus is employed by the J. Richard firm in exhibiting projection of stereoscopic pictures obtained with the verascope.

The "stereo-project," made by Demaria, and shown in Fig. 2, is identical in principle with the foregoing. A single pair of mirrors may be employed to displace one projection, the other being seen directly, as in Fig. 3. The difference in length of the paths traversed by rays from the two pictures is insignificant in comparison with the distance of the observer from the screen. This device was proposed, a few years ago, by Lieut.-Col. Moessart and M. Knight, independently, and has been realized in Bellieni's "apedioscope" (Fig. 4). Drouin's stereoscope (Fig. 5) is based on the same principle but employs a reflecting prism instead of mirrors. As the mutual inclination of the reflecting surfaces and, consequently, the displacement of the image, is unalterable, the apparatus will not produce perfect superposition at distances much less or greater than the mean distance for which it is designed, except at the cost of eye strain.

A prism or prisms may also be used to displace one or both images by refraction, for the displacement and, consequently, the refracting angles required are so small that both the distortion of the image and its coloration by dispersion of light may be neglected.

Fig. 6 illustrates the principle of the method as employed by Buguet, and also by Macé de Lépinay. It has the advantage of making the individual apparatus very simple and light, for the prisms may be mounted and worn like spectacles or eye-glasses. But as the displacement required varies with the distance from

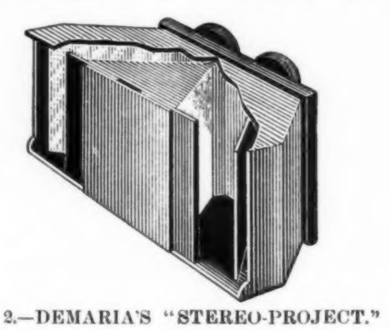


FIG. 2.—DEMARIA'S "STEREO-PROJECT."

the screen each spectator must have prisms of an angle determined by his location. With pictures three feet square, for example, four sets of prisms, with angles of 6 deg., 8 deg., 10 deg., and 12 deg., are required to cover satisfactorily all distances from 15 to 30 feet. This complication greatly restricts the employment of the apparatus.

In 1895 Moëssart devised his "stéréo Jumelle," containing two prisms which can be turned about vertical axes in order to vary the displacement of the images.

In all these devices the images are merely combined without being magnified. Mattey and Papigny have obtained both effects, as in the common stereoscope, by a simple modification of the ordinary opera glass. In the latter the axes of the two telescopes are parallel in order to permit both eyes to see the same distant point (Fig. 7, *a*). If these axes are made to diverge by increasing the distance between the objectives, two separate pictures may be superposed by eccentric refraction, as indicated in Fig. 7, *b*. The apparatus, in

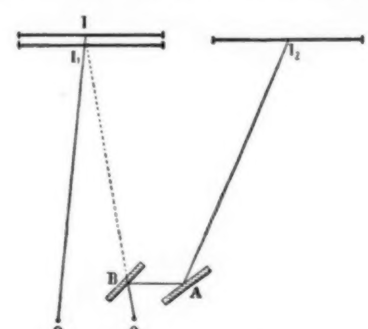


FIG 3.—DIAGRAM OF "APEDIOSCOPE."

fact, becomes the ordinary hand stereoscope (the "prisms" of which are really segments of lenses) with the addition of concave eyepieces. If, on the contrary, the objectives are brought nearer together than the eye-pieces so that the visual pencils pass through their outer halves, the right eye sees the left-hand picture, and conversely, producing inverse or pseudoscopic relief if the pictures are arranged in the usual way, and correct stereoscopic relief if they are transposed. Now it is a well-known fact that such transposition occurs in the camera in the very act of taking the stereoscopic negative and that the positives have to be re-transferred for use in the ordinary stereoscope. This second transposition may be avoided by the use of the converging opera glass just described. Fig. 8 shows the actual apparatus, which is called the "stereo-tele-

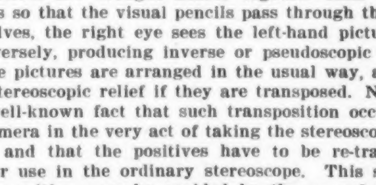


FIG. 4.—BELLIENI'S "APEDIOSCOPE."

scope." It is provided with the usual focusing device and also with a screw for regulating the distance between the objectives. The axes may, therefore, be made to diverge, or converge, to suit the distance from the screen, or they may be made parallel, thus converting the instrument into an ordinary opera glass. The stereo-telescope has the defect of smallness of field common to all Galilean telescopes.

Furthermore, all the devices described above are open to two objections. As two pictures are projected side by side, each is only half as large as it could be made if it occupied the whole screen, and two lanterns or one very large one, are needed. If only one is used its condensers must be at least 7 inches in diameter

for ordinary 3½ x 7 stereoscopic slides, and 4½ inches for the smaller verascope pictures.

SUPERPOSED PROJECTIONS.

1. Apparatus with Continuous Illumination.

The two pictures are projected so that each of them fills the entire screen, and each is then selected from the blurred resultant picture and conveyed to the proper eye by suitable means.

A method of accomplishing this result by the use of

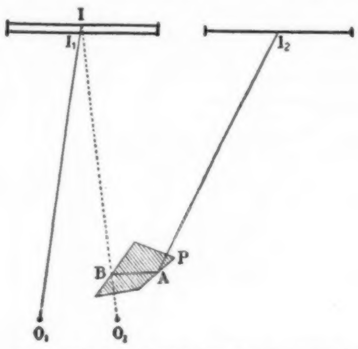


FIG. 5.—DIAGRAM OF DROUIN'S STEREOSCOPE WITH REFLECTING PRISM.

colored glasses was proposed by Almeida in 1850, and was the earliest solution of the problem of stereoscopic projection. To fix the ideas, suppose that the lantern slides used are ordinary black and white positives and that the right-eye picture is covered, in the lantern, with a red glass, and the left-eye picture with a green glass. Then, as red and green are complementary colors and exclude each other, it is clear that, if the right eye of the observer is also covered with a red glass and his left eye with a green glass, each eye will see only the picture intended for it and thus the effect of stereoscopic relief will be produced. If, on the other hand, the lantern slides are positives print-

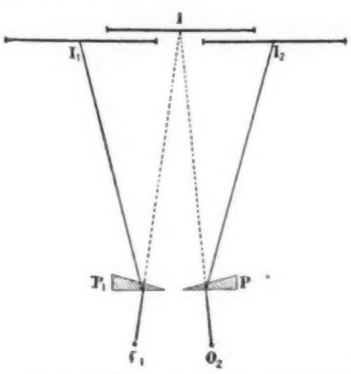


FIG. 6.—DIAGRAM OF STEREOSCOPE WITH REFLECTING PRISMS.

ed, not in black, but in transparent colors, the right-eye slide being red and the left-eye slide green, no colored glasses should be used in the lanterns and the eye-glasses should have tints complementary to those of the respective slides—that is to say, the right eye should look through a green glass and the left eye through a red glass. This may be made clear by writing with red ink on white paper and viewing the writing through red and green glasses successively. The writing cannot be seen through the red glass because the whole sheet appears red, but through the green glass the letters appear black on a green ground. By Almeida's method the projections may be made as

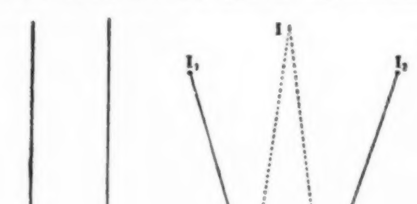


FIG. 7.—DIAGRAM OF MATTEY AND PAPIGNY'S OPERA GLASS WITH MOVABLE OBJECTIVES.

large as the screen but two lanterns, or one very large one, are still required.

M. Ducos du Hauron, well known through his inventions in three-color photography, conceived the ingenious idea of printing the right-eye and left-eye pictures, one over the other, on the same plate of glass, not in continuous washes but in a fine stipple like that produced by gratings in photo-engraving, and in complementary colors. In these conditions the pictures do not interfere with each other and the surface to be illuminated is reduced one-half.

But unfortunately, colored eye-glasses absorb a great deal of light, and it is practically impossible to make them exactly complementary, so that, even with intense illumination, the resultant combined image is dim and of undesirable tint.

Several writers have suggested projecting the pictures by beams of light polarized in planes at right angles to each other, and viewing the projections through Nicol prisms with their principal planes arranged accordingly, but this method is too cumbrous and costly to have any but theoretical interest and cannot be regarded as a practical solution of the problem of stereoscopic projection.

2. Apparatus with Intermittent Illumination.

In contrast with all these devices is one which merits especial attention, and which introduces, as a new element, the well-known property of the persistence of impressions on the retina.

Suppose that the two pictures are projected centrally on the screen, but that they are illuminated, not continuously but intermittently and alternately. This result may be accomplished by placing in front of them a rapidly rotating screen which masks them alternately. Each will appear on the screen as a continuous picture, confused with the other, by reason of the persistence of visual impressions.

Suppose, further, that a second screen, rotating in

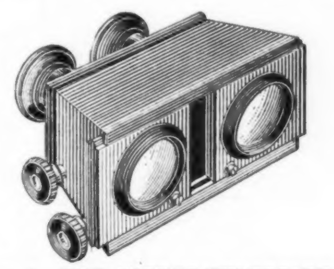


FIG. 8.—THE STEREO-TELESCOPE.

absolute synchronism with the first, is placed before the eyes of the observer, so that each eye is uncovered when the corresponding picture is projected on the screen, and covered at other times. Evidently each eye will see the picture intended for it, and not the other, and the stereoscopic effect will be obtained.

Figs. 9, 10, 11, and 12 illustrate the apparatus designed, in accordance with these principles, by Dupuis and Schmidt. There is a single lantern, *S* (Fig. 9) with one condenser, *C*, but two projecting lenses, O_1 O_2, placed respectively before the slides, I_1 I_2. At the moment represented by the diagram the slide, I_1, alone is illuminated, by reflection from the fixed mirror, M_1. A M_2 is a semi-circular mirror, filling half of a circular frame (shown above) and rotating in its own plane about *A*. After a half rotation the mirror, A M_2, will intercept the beam of light and reflect it on the slide,

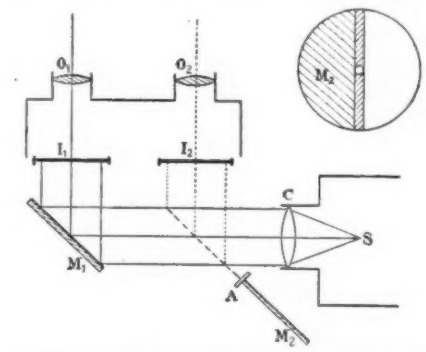


FIG. 9.—DIAGRAM OF DUPUIS AND SCHMIDT'S LANTERN.

I_2, leaving I_1 in darkness. In this way the two pictures are projected alternately. The analyzing apparatus placed before the eyes of the observer consists essentially of a double pallet, P_1 P_2 (Fig. 10), which oscillates in such a manner as to cover the left eye and uncover the right eye when the right-eye picture is on the screen, and conversely. The oscillation is effected by an electromagnet which acts on the pallet and is connected with a battery and a commutator attached to the axis of the rotating mirror of the lantern. In practice the pallet and its mechanism are inclosed in an opera glass (Fig. 12). I have seen this apparatus in operation. It gives the screen pictures a fine relief and perfect steadiness, with 30 or 40 alternations per second. There is none of the disagreeable and fatiguing trembling observed in ordinary moving pictures. It is a curious fact that it is not even necessary, in order to obtain this steadiness, to project the centers of the pictures exactly to the same point of the screen. Even with a divergence of 4 inches, which produces very great confusion when they are regarded with the naked eye, they combine in the intermittent opera glass, without ocular effort or fatigue, to form an image in relief, perfectly sharp and absolutely motionless.

Now, the cinematograph also employs intermittent illumination, using the interval of darkness for the substitution of one picture for another. Dupuis and Schmidt, therefore, were naturally led to attempt the production of stereoscopic moving pictures by using two bands of film, taken for the right and left eyes respectively, and moving and illuminating them alternately, so that a picture of one series is illuminated and projected while the other band is being shifted in darkness. I have seen a number of such stereoscopic moving pictures which enhanced the illusion of motion in the happiest manner by adding to it the effect of relief.

Of all the devices yet proposed for stereoscopic projection this certainly seems to me to be the best.—Prof. E. Colardeau, in La Science au XXme Siècle.

THE PASSING OF AN INDUSTRY.

IN some old Lancashire village the observant will often notice among the old gray-slated cottages some

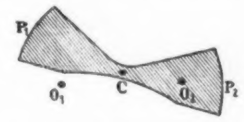


FIG. 10.—OSCILLATING PALLET.

that have windows of apparently disproportionate size, glazed in the old-fashioned way with many little panes, set in a whitewashed framework. But it is the unusual size of some of these windows, stretching as they do almost the whole width of the room they were designed to light, that may puzzle some of those who are unfamiliar with them. Such prodigality of light seems out of keeping with the traditions of the cottage architecture of that date.

A sound comes out through an open door that furnishes a clue to the mystery—it is the unmistakable "clickety-clack" of a handloom. It seems incredible that anyone should be working a handloom in Lancashire in the twentieth century. Yet here in this village there are handlooms in full swing still, though they are now but few, much fewer than they were even five years ago—these last five years have been hard on the old generation. The fact is that these wide-windowed cottages were the weaving-sheds of one or two centuries ago, when silk was still the staple industry of Lancashire, when cotton was in its

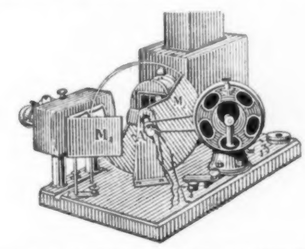


FIG. 11.—DUPUIS AND SCHMIDT'S INTERMITTENT PROJECTOR.

infancy, and coal was a luxury raised by horse-power from a few "gin-pits." In those days such a room as this which we enter now would have as many as four looms on the same wide stone flags that still form its flooring, and the long window was necessary to light them, for the setting of the warp is delicate work. Now the looms are reduced to one, worked by an aged woman who has returned to the wage-earning of her girlhood after launching a family of twelve into the world. In another corner her husband plies his trade of cobbler. He is an old man with club-feet, but stout and seemingly defiant of time. With his leather cap and apron, his few primitive tools and large shallow box divided into little square compartments for wooden pegs and different kinds of nails, bristles, and thread, and cobbler's wax, he might sit for the pictu.. of the rustic industry of a bygone generation. The .oom it-

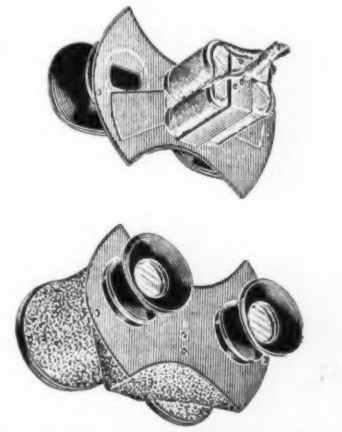


FIG. 12.—INTERMITTENT OPERA GLASS.

self, too, has the very countenance of old, forgotten days, with its massive uprights of worm-eaten black oak. To an eye unspoiled by the almost diabolic cunning of modern power-driven machinery it seems a monument of human ingenuity, with its quaint and rickety paraphernalia. The threads of the warp are stretched in double series, crossing each other w all the neatness of the spider's art. A wooden p

actuates the gear above, which alternates their interlacements, while the simultaneous action of the staff held in the hand of the weaver keeps the shuttle flying to and fro, and at the same time the old machine jerks out a little more and a little more of the finished fabric.

The pale fibers of the warp have done nothing to prepare us for the superb deep rose of the silken piece that is being thus slowly wrapped around the roller. Its glow, as of outspread jewelry, and the rustling opulence of its texture form a strange contrast to the dim monotony of the cottage interior—a glorious opportunity for the *genre* painter. One wonders that such stuff—destined, no doubt, to be the worthy robe of beauty amid surroundings as splendid as itself—should display its new-born loveliness against this background of dull, lime-washed walls and gray-flagged floor—should ever have been associated with the cheap oleograph almanac on the wall—advertisement of some inartistic grocer—with the home-made hearthrug of red and black rags, the cheap mahogany rocking-chair that has replaced the old oak "settee," and all the frowsy stock-in-trade of the cobbler and the broken, misshapen boots of his customers, or should be wrought by this work-withered old woman for sixpence-halfpenny a yard! That, we learn, is the handloom weaver's pay. It seems little enough for the work, but again we wonder how the old woman can compete with steam. The idea of a hand-loom for cotton the mind declines to contemplate—what, then, is the difference in the trades? Does it depend on the different values of the raw material? The cottagers have no answer to these questions. They only know that they can still obtain the silk from Mr. X., in the town hard by, and receive their sixpence-halfpenny a yard for the "cut," just as their "rude forefathers" did, though not so regularly now. It has not occurred to them that they are an economic curiosity.—Manchester Guardian.

PROGRESS OF OPTICAL SCIENCE AND MANUFACTURES.*

The study of optics is a fascinating one, and its history full of interest. I do not propose to-night to attempt to cover the whole ground, but to ask you to look at one or two special periods during which, it seems to me, theory and practice reacted on each other in a marked manner, and to consider what lessons we may draw as to the relation which should in these days of ours subsist between the two.

For this purpose I might go back to very early days. Ptolemy in his attempt to discover the laws of refraction—and wonderfully good the attempt was, as we know now—Archimedes with his burning glass, if, indeed, he ever made it, had both practical aims in view. But we will start to-night nearer our own time. The end of the seventeenth century is such a period. The telescope was invented about 1608, the microscope at rather an earlier date, about 1590, both, probably, in Holland.

Galileo, hearing of this, made his first telescope in 1610. In 1611 Kepler, in his "Dioptrica," described the astronomical telescope with one or more convex lenses as the eye-piece; with this exception, up to Descartes' book on "Dioptrics" in 1637, no other form of telescope but Galileo's was known. The law of refraction was first enunciated by Snell in 1621.

Thus by the year 1660 the importance of the telescope to the astronomer was fully appreciated, and its limitations were being realized. In 1663 Gregory published an account of the first reflecting telescope designed to meet some of these defects, and about this time two men, whose work has left indelible marks on the science, were led to study it in a great measure from their interest in astronomy—Christian Huyghens, who lived from 1629 to 1695, and Isaac Newton, 1642 to 1727.

Huyghens was the discoverer of the wave theory and of the law of double refraction, but he was also a skilled mechanic, and he worked himself at grinding his lenses and e[illegible]ing his telescopes. He realized from a consideration of the theory that many of the most marked defects were due to the fact that the rays from a distant star traversing the various parts of the lens were not brought to a focus at the same point on the axis, and that for a lens of given aperture this axial aberration decreased rapidly as the focal length increased. The magnification of the telescope depends on the ratio of the focal length of the object glass to that of the eye-piece. Hence by keeping this ratio constant, and increasing both focal lengths in the same proportion, the magnification could be maintained and the spherical aberration decreased.

Thus he was led to make lenses of 120 feet focal length. Tubes for such instruments could not be produced, and they were mounted on the top of tall poles and moved from below by ropes. With one of these telescopes, which he afterward presented to the Royal Society, he discovered Saturn's rings and its fourth satellite. In this case the desire to improve an instrument caused an appeal to theory, and theory led the optician to make a real advance. The advance, it is true, was an inconvenient one, and the defects, as we shall see, were not entirely due to spherical aberration, but the fact remains.

In another branch of instrument making Huyghens is famous for applying science to manufacture. His treatise "Horologium Oscillatorium," which discussed most ably many problems of motion, was long the standard work on clocks, and he was the first to bring into practical use, in 1657, the pendulum as a regulator for time measurements, though according to Sir E. Beckett the first pendulum clock actually made was constructed in 1621 by Harris, of London, for St. Paul's Church, Covent Garden.

In 1665 a posthumous work of an Italian Jesuit, Francis Maria Grimaldi, entitled "Physico Mathesis de Lumine, Coloribus et Iride aliisque annexis," was published at Bologna. It contains some notable observations, particularly the discovery of diffraction.

Newton, who in the previous year had taken his B.A. degree at Cambridge, purchased a prism at Stourbridge Fair in 1666 "to try therewith the celebrated phenomena of colors," and to repeat some of Grimaldi's experiments. During that year also he had applied himself to the grinding of "optic glasses of other figures than spherical." He was already interested in astronomy, possibly had already made, but not confirmed, his great discovery. Writing to Halley in 1686 about some of the controversies which followed the publication of the "Principia," he says: "But for the duplicate proportion I gathered it from Kepler's theorem about twenty years ago."

The celebrated apple is supposed to have fallen in his mother's garden at Woolsthorpe, in Lincolnshire, in 1665, where he was driven by the plague, and the story has some authority. It is stated to be the fact by Conduitt, the husband of Newton's favorite niece; it was told by Mrs. Conduitt to Voltaire, and the tree from which it was said to have fallen was seen by Sir David Brewster in 1820.

Various suggestions have been made, for the reason why the discovery that the same cause which produced the apple's fall also maintained the moon in her orbit was not published for many years; the true one is probably due to Dr. Glaisher, who pointed out that it was necessary to know the attraction not merely between two particles of matter, but between two spherical bodies of large size, and that this problem was not solved until much later; but, be this as it may, we are sure that in 1667 Newton was an astronomer, and realized the necessity for accurate astronomical observations, and all that the improvement of the telescope meant to astronomers.

Now his experiments with the prism in 1666 led to the discovery of the spectrum; little was known about colors at that time, and Dr. Barrow's "Treatise on Optics," published with Newton's help in 1669, contains very erroneous views; but some time shortly after that date Newton was able to draw the important conclusion that white light is not homogeneous, but consists of rays some of which are more refrangible than others; the pictures of the spectrum, so familiar to us in numerous text-books, come from Newton's "Optics," published first in 1704, though his discoveries as to the analysis of white light were laid before the Royal Society in various papers in 1671, and were given in lectures on optics as Lucasian professor in Cambridge in 1669, 1670, and 1671.

The bearing of all these physical experiments and researches on the practical manufacture of the telescope was at once obvious; the lenses behave like prisms, and decompose the light into its constituent colors. No alteration of shape will remove this entirely, and Newton was driven, too hastily as we know now, to the conclusion that the refracting telescope could not be greatly improved; its defects were inherent in the refraction of light.

The defect, however, does not exist in images formed by reflection, and he came to the conclusion that optical instruments might be brought to any degree of perfection imaginable provided a reflecting surface could be found which would polish as freely as glass and reflect as much light as glass transmits, and provided a method of communicating to it a parabolic figure could be found. In 1668 he thought of a delicate method of polishing by which he believed "the figure would be corrected to the last," and the Newtonian reflecting telescope was the result. An instrument made with his own hands is now in the possession of the Royal Society, and the many noble instruments which have added so greatly to advance our knowledge of the stars are the direct outcome of Newton's experiments with the prism and the deductions he drew from them.

But these experiments convey another lesson, for Newton, misled by his observations on dispersion, decided, wrongly, as we know now, that achromatic lenses were impossible, and that the color defects must always exist in reflecting instruments; and as a result attempts to improve these instruments were almost in abeyance for nearly ninety years. Two or three achromatic telescopes were made by Mr. Hall about 1730, but it was not until 1757 that Dolland re-invented this instrument and commenced the regular construction of such lenses.

Thus the discoveries of Huyghens and of Newton reacted powerfully on the instruments of their day. Indeed, in each of these two instances the discoverer and the instrument maker were the same person. Such a combination may be less possible now; still, there are mathematicians skilled in the theory of optics and opticians skilled in the practice of their art.

The Optical Convention aims at co-ordinating the efforts of the two. But if two hundred years ago the progress of the telescope was determined by the advance of optical theory, theory itself was no less indebted to the interest in instruments and observations thus aroused for the progress that took place.

Huyghens was the founder of the wave theory, though the labors of Young and the genius of Fresnel were necessary before Newton's rival theory of emission was displaced.

For nearly one hundred years after the date of Newton's "Optics" progress was slow. The world was occupied in assimilating what he had taught. English mathematicians, overawed, perhaps, by his transcendent greatness, employed themselves in expounding his teaching. In England, at any rate, the emission theory was supreme, and few, if any, questioned his dicta as to the impossibility of achromatism.

But a change came with the new century. Thomas Young (1773-1829) was the first in his various papers between 1801 and 1811 again to direct attention to Huyghens's work, and to place on a firmer basis the ground-work of the wave theory. He it was who established clearly the principle of the superposition of waves and showed how interference may be explained by it.

Young's work, however, would have been incomplete without Fresnel (1788-1827), who re-discovered for himself the principle of interference and extended it to explain diffraction, besides enunciating his theory of double refraction and deducing the well-known expressions for the intensity of the light reflected from or transmitted by a transparent surface.

Young, in his "Lectures on Natural Philosophy," illustrated in an admirable way the applications of optical theory to instruments. Fresnel was an engineer by profession attached to the service of the bridges and roads, and as such was the inventor of the arrangements of lenses employed in the French lighthouses.

The discoveries of these two men changed the whole of the theory on which the construction of optical instruments is based; it is idle to attempt to explain the action of a microscope, the resolution of a double star or of the fine lines of the spectrum, to discuss the conditions for such resolution, or, instead, to attempt the construction of any of the more delicate of the beautiful apparatus about us without clearly understanding the fundamental laws discovered by these two, and verified with marvelous skill by Fresnel in his country home in Normandy, not by the aid of modern apparatus, but by such means as his own hands, aided by the skill of the village blacksmith, could construct; and though it is true that only recently have we appreciated the full importance of the wave theory in its bearing on the construction of optical instruments, it is the fact that without their labors and the work of those who followed in their path few of the modern discoveries of the astronomer, few of the results which the skilled optician of to-day has arrived at, would have been possible. The object glass of a microscope, the lens of a camera or a telescope, have reached their present perfection because men have been found who could apply to the art of lens grinding the highest teaching of Young and of Fresnel.

In the earlier years of the last century Englishmen were well to the fore in this work. In astronomy the labors of the two Herschels are well known, and though, perhaps, the success of the elder Herschel was due rather to his mechanical skill than to a profound knowledge of optical theory, Sir John Herschel advanced in no small measure the application of theory to practice.

At a somewhat earlier date Fraunhofer, of Munich (1787-1826), a contemporary of Young and of Fresnel, had realized the fact that the development of the achromatic lens "depended on the exact determination of refractive indices, and that the chief difficulty in that determination lay in the difficulty of obtaining homogeneous radiations to serve as standards" (Schüster, "Theory of Optics").

For these he used the dark lines of the solar spectrum, originally observed by Wollaston, and in this we have an example of the manner in which practical needs react to assist in the advance of science, for from these observations springs the whole of spectrum analysis and all that is involved in that.

Thus theory and practice progress together; each alone carries us but a short way, but the judicious use of hypothesis and reason, supported by the verdict of experiment, carries us on to new knowledge, and brings us nearer the truth.

Until after the middle of last century we in Britain took our full share in promoting this advance. We might add to the names already mentioned those of Sir George Airy and of the distinguished men who, in the first half of the century, adorned Trinity College, Dublin, notably Sir William Hamilton.

Sir George Airy gave, about 1802, an account of the aberration of the lens of the camera obscura of the utmost value to the early designers of the photographic lens, while Sir William Hamilton's essay on the "Theory of Systems of Rays" contains the essence of all that is needed to calculate to a high degree of accuracy the aberration of such a lens.

But at that date photographic lenses were not thought of, and when Daguerre announced his invention in 1839 the work of Airy and of Hamilton was forgotten. Thus to quote, as I did lately in the Traill Taylor lecture, from the recent work of Dr. M. von Rohr:

"The important signification of Airy's writings for photographic optics does not seem to have been appreciated until a later date. Although they exercised an influence on English text-books, like that of Coddington, they seem unfortunately never to have become known in wider circles on the Continent. It appears, then, that the theoretical opticians of later years to whom his investigations into the astigmatic deformations of oblique pencils would have been of great interest did not base their work on that of Sir G. B. Airy," while Sir W. Hamilton's paper remained unnoticed by the optician until Finsterwalder directed attention to it, and another distinguished German, Prof. Thiessen, quite lately put his results into an accessible form.

There was a divorce between theory and practice in England. The importance of Daguerre's discovery was at once realized, and English opticians set to work with no small success to develop the lens and to make it perfect, and splendidly in many ways they performed

* From the inaugural address delivered before the Optical Convention on May 30 by the president, Dr. R. T. Glazebrook, F.R.S.

their task; but the work was empirical. A certain amount of progress was possible, and was achieved, but without the guidance of well founded theory the progress could not be for long.

The learned Transactions of the Cambridge Philosophical Society and of the Royal Society of Dublin were perhaps the last places to which the practical optician would apply for help, and so it came about that because the opticians of another nation first recognized that a full knowledge of the action of a lens on the light that traverses it was a condition precedent to further truth, for some years past the great improvements in the products of the optician's skill which have taken place have had their origin mainly in Germany.

This brings me to our last example of the manner in which science and practice may combine to produce effects unattainable by either singly. But before dealing with this I would mention one great advantage which, until a few years ago, the English optician possessed in a special degree, an advantage to which much of the progress of our English lenses is undoubtedly due. The story of Gunand's invention of optical glass is deeply interesting. A poor carpenter, and later a watch-case maker, of Brenetz, in canton Neuchatel, he was born in 1740, and became at an early age interested in telescopes. Prompted by the desire to possess a pair of spectacles, he undertook to make the glass for the lenses. A little later, through M. Droz, a gentleman of the neighborhood, he was allowed to examine one of Dolland's achromatic lenses, and learned of the difficulty of obtaining the flint glass required. This he determined to make, and years of penury and unremitting toil followed, until at last he succeeded in casting disks sufficiently homogeneous to be used for optical work.

Fraunhofer persuaded him to migrate to Munich, but the venture was not a success. He returned to Switzerland, and again started glass making. After his death his son told the secret of the art to George Boutemps, a Frenchman, who some years later was brought to England by Messrs. Chance, and helped them to establish the optical glass works which for so long were practically the sole source of the supply of raw material for the optician.

Our catalogue to-day bears witness to the progress in glass manufacture that has taken place since Boutemps's time, and it is right to recognize the influence that progress has had on opticians' work.

But to return to our main subject. An optical convention in 1905 would be incomplete without some reference to the work of that master optician who a few months ago was taken from us, the more so since the work of Ernst Abbe affords perhaps the most striking illustration of the effects of the reasoned combination of theory and practice. A comparison of the statistics of the optical trade of Germany now and twenty years ago will suffice to prove this.

The story of the growth of the Jena industry has been told frequently, still I will repeat it in barest outline. Abbe, then a young man, had settled at Jena as a privat docent in 1863, and soon after Carl Zeiss, who then made microscopes of the ordinary class, applied to him for help in the development of the instrument. Abbe's task was a hard one; the theory of the microscope was at that date only partially understood, the corrections to the lenses were made by a rough trial and error method, and the results were doubtful. The first step was to solve a mathematical problem of no small difficulty, to trace the paths of the pencil through the object glass. Abbe soon realized the defects of the ordinary theory. He found it necessary to apply the principles of the wave theory, the teaching of Young and Fresnel, to the problem, and was led in 1870 to the theory of microscopic vision which bears his name. His work was the direct outcome of that of Fresnel.

He soon realized that it followed from the mathematical theory that with the glass then at the optician's disposal no great improvement in the microscope object glass could be expected. Certain relations between the dispersion and refraction in the various lenses were requisite to secure achromatism, and no glass having these relations existed. An inspection of the instruments in our loan exhibition at South Kensington in 1876 confirmed this view, and he published it in a report in 1878 on the results of the exhibition: "The future of the microscope as regards its future improvement in its dioptric qualities seems to be chiefly in the hands of the glass maker."

The investigations of Petzvel and of von Seidel led to a similar result with regard to photographic lenses. Von Seidel's work dates back to 1856-7, but his main paper was not written until 1880, after the date of Abbe's report, and was not published in full until 1898.

It follows from these investigations that with the glass then on the market, it was impossible to make the field of a photographic lens at once flat and achromatic.

Thus the theoretical work indicated a bar to future progress which could only be removed by the manufacture of new glasses having certain definite properties. It is fitting to say that at an earlier date this fact had been recognized by our countrymen, Mr. Vernon Harcourt and Prof. Stokes, who for some eight years previous to 1870 had endeavored, but with scant success, to make the glass required.

Abbe was more fortunate; his report fell into the hands of Dr. Otto Schott, a glass maker of Witten, in Westphalia, who realized its importance. In 1881 Schott communicated with Abbe, and the next year he removed to Jena, and the firm of Schott and Partners was born.

In the first catalogue of the Jena Glass Works they write: "The industrial undertaking here first brought into public notice and which has arisen out of a scientific investigation into the dependence between the optical properties and the chemical composition of solid amorphous fluxes was undertaken by the undersigned (Schott and Abbe) in order to discover the chemico-physical foundations of the behavior of optical glass." The inquiry was aided by large grants from the Prussian Minister of Education. The practical result is seen in the catalogue of the Jena firm and the enormous export of German optical goods.

Nor is this all, for in virtue of the distribution of profits settled by the scheme of the Carl Zeiss Stifting, drawn up by Abbe some years ago and ratified by the Bavarian government, the University of Jena alone has received a sum approaching £100,000. Abbe's work at Jena is perhaps the most striking illustration of the way in which progress depends on the co-operation of science and experience. One could give statistics to illustrate the truth of this and the important effect it has had on German trade and prosperity. They are hardly necessary; the facts are patent, and their cause well known to all who care to inquire. We can progress, too, if we follow the path laid down for us of old by Newton, Young, Herschel, Airy, and the others of whom I have spoken.

ARMY SANITATION IN MANCHURIA.

THE remarkable address that was delivered before the Committee on Military Affairs of the House of Representatives by Major Louis Livingston Seaman, M. D., of New York, not long ago, has just been published in full in Clinical Excerpts, and will undoubtedly prove of interest to military surgeons everywhere. Dr. Seaman complains that the importance of the Medical Department of the United States Army has never been recognized, and calls attention to the fact that, in all the wars in which the United States has been engaged, disease has carried off more than 80 per cent of the combatants who have died, more than half of which was easily preventable. The statistics of the wars and of the Pension Department prove that if we could prevent this tremendous and unnecessary loss from disease, we would save in pensions alone, in less than twenty years, the entire cost of each war.

Unless our Medical Department is put on a higher plane, the major tells us, where it can exercise the power of direction and supervision, unless it is elevated and fortified with the power necessary to carry out its purposes, we will have a repetition of the sad experiences we have had heretofore, in the next emergency that arises in the country. "Every death from preventable disease," says he, "is an insult to the intelligence of the age. When it occurs in an army, it becomes a governmental crime."

Dr. Seaman was with the Japanese army, and is thoroughly posted on the condition of affairs in it. This gives particular weight to his assertion that the Japanese would never have won that series of brilliant victories from the Yalu to Mukden unless they had had their army in the most magnificent physical condition, and that they would not have been in that condition if they had not had the most thorough sanitary government and control that any army ever yet had in all history.

The author refutes the contention that the Japanese are built differently from our people, and that it is therefore unfair to make comparison with them, and points to the fact that only a few years ago, in their fight with Korea, the mortality of the Japanese was nearly as great as ours in the rebellion. One disease alone, beriberi, laid out 45 per cent of their whole army. Now, simply because they have better sanitation and proper medical supervision and diet, there has not been a single case in the navy this year.

Six months' continuous service in a torpedo boat in our navy, or in the English navy, we are informed, is considered about enough to incapacitate a man and make him unfit for duty until he gets a good rest. But after six months' service on their torpedo boats before Port Arthur (which the doctor had an opportunity to inspect) the Japanese marines were in the pink of physical condition, and simply primed for more work.

In describing the medical and sanitary organization of the Japanese army, Dr. Seaman pays a high tribute to its efficiency.

He says: "They have a medical director of their army who ranks as a lieutenant-general; they have six officers who rank as major-general; they have one who ranks as brigadier-general with every 20,000 men in the line, and these medical officers have power to enforce their orders.

"The Japanese soldier would die from thirst alongside of a tainted well rather than drink water that he had been forbidden to take. He has confidence in his officers, and even if he had not, he would be severely punished if he undertook to disobey sanitary orders. It would not be necessary to go to the commanding officer of the line to get the order, either. Without power to enforce its discipline, sanitary organization would amount to practically nothing. To prevent a repetition of the same wretched experience as we went through in the war with Spain, the medical department must be vested with power to enforce its regulations. The fixing of high rank with the emoluments that accompany it should go hand in hand with the power to enforce such regulations as might be prescribed.

"This would prevent such an incident as occurred in Chickamauga in 1898, when a major-general of the army, after a medical officer had declared a certain well unfit for use as containing germs of disease, drank a glass of the water before his staff in defiance of the surgeon's prohibition, making the latter the laughing stock of his associates, saying: 'The water is perfectly good; I will drink it.'

"At Tampa, during the Spanish-American war, a major-general set at defiance the authority of the Deputy Surgeon-General, when the latter had a ship loaded with medical supplies ready to sail with the army. 'Discharge that cargo, and load the vessel with mules and men,' was his order. And he sent the whole army to sea and to battle without any medical supplies whatever. You are aware of the horrible results that followed. Under different conditions that major-general would have been court-martialed; he would have been taught to respect the medical department.

"I was at Hiroshima last summer when 9,860 men were brought from the front. Of that entire number, only 34 died. The vast majority of them got well and returned to the front. There were 1,106 transferred to Tokio, a great many stretcher cases, and of that number not a single man died, although they were shot in almost every possible way. Six of them had bullets through the brain in different directions. Nine had bullets through their chests. Six had bullets through the abdomen, the point of exit and of entrance being discernible in all cases. And they all got well. That was principally because they were fed on a rational ration, and their systems were not loaded with uric acid and other toxic substances that excite inflammation after injury and cause death.

"From personal experience with the Japanese army and navy, I must say that too much praise cannot be bestowed upon the medical department for its splendid preparatory work for this war. The Japanese are the first to recognize the true value of an army medical corps. Care of the sick and wounded consumes but a small part of their time. The solution of the greater problem, preserving the health and fighting capacity of the army in the field, of preventing disease by careful supervision of the smallest detail of subsistence, clothing, and shelter of the troops, is their first and important duty. Their capacity for detail is something phenomenal. Everywhere—in the field with the scouts or in the base hospitals at home—the one great prevailing idea is the prevention of disease. The medical officer was omnipresent. He was found in countless places where in an American or British army he is not wanted. He was as much in the front as in the rear. He was with the first screen of scouts with his microscope and chemicals, testing and labeling wells, so the army to follow would drink no contaminated water. When the scouts reached a town, he immediately instituted a thorough examination of its sanitary condition, and if contagion or infection was found, he quarantined and placed a guard around the dangerous district. Notices were posted, so that the approaching column was warned, and no soldiers were billeted where danger existed. Microscopic blood tests were made in all fever cases, and bacteriological experts fully equipped formed part of the staff of every divisional headquarters.

"The medical officer also accompanied foraging parties, and, with the commissariat officers, sampled the various foods, fruits, and vegetables sold by the natives along the line of march long before the arrival of the army. If the food was tainted or the fruit overripe or the water required boiling, notice was posted to that effect, and such is the respect and discipline of every soldier, from commanding officer to the file in the ranks, that obedience to all orders is absolute.

"The medical officer is also found in camp, lecturing the men on sanitation and a hundred and one details of personal hygiene; how to cook, to eat, and when not to drink; to bathe, even giving them directions as to the care and cleansing of the finger nails to prevent risk from bacteria. Long before the outbreak of hostilities he was with the advance agents of the army, testing provisions that were being collected for troops that were to follow, and as a consequence of these precautions he is not now found treating thousands of cases of intestinal diseases, diarrheas or dysenteries, infectious fevers resulting from improper feeding and neglect of sanitation, diseases that have brought more campaigns to disastrous termination than the strategies of opposing generals or the bullets of their followers.

"It is much too early to submit statistical proof; but from careful observation I venture to predict the records of the Japanese hospitals will show a large reduction in the percentage of mortality from casualties, especially penetrating wounds of the skull, chest, and abdomen, and injuries to osseous structures—indeed, of every variety of wounds, except, perhaps, those of the spinal cord—when compared with the statistics of former days. But it is in that far more terrible and pathetic class of losses, the needless sacrifice of 400 lives by preventable diseases for 100 who die legitimately, that the most astounding reduction will be shown. If the testimony of those conversant with the facts can be accepted, supplemented by my own observations, the loss from preventable diseases in the first six months of this terrible conflict will be but a fraction of one per cent. This, too, in a country notoriously unsanitary. Compare this with the fearful losses of the British from preventable disease in South Africa, or worse, with our own losses in the Spanish-American war.

"Regardless of the ultimate outcome of this terrible war, history will never furnish a more convincing demonstration of the benefit of a medical, sanitary, and commissary department thoroughly organized, equipped, and empowered to fight the silent foe. The Japanese do their killing, but they do it differently. They, too, have their tragedies, but they are legitimate tragedies of grim war, not governmental murders through criminal neglect.

"The ration of the Japanese is controlled by the medical department, which has thoroughly experiment-

ed with it, and at last established it on an efficient scientific basis. It is the simplest ration in the world—mostly rice and a little bit of meat, a few pickles, and some dried fish. It is a ration the constitution of which would not be practicable for our people, but its chief and best characteristic is its simplicity. It costs about one-tenth of ours. Our ration is all right for a cold country—for an Arctic climate; but for a tropical country it is the height of absurdity.

"The Japanese are a very poor people. Economy is the very first point upon which they have to base their calculations, and yet they can afford, and do afford, to furnish 648 men for each army division, as against our 82.

"In all the Japanese hospitals there was last summer a very small percentage of sickness in comparison to wounds. I saw ward after ward for the treatment of internal diseases, diarrhea, dysentery, typhoid, and so on, comparatively empty. They do not have these diseases. They take proper care of their men in advance, so they do not contract these diseases. Their hospitals are for the care of casualties caused by shell and shrapnel. The other cases are absent."

The conclusion of the address was a powerful plea for a reorganization of the United States Army Medical Department. To increase its efficiency, Dr. Seaman insists, its head should be supreme in his department. He should take orders from no one except the Secretary of War and the President of the United States. He should have sufficient rank (at least that of major-general) to see that his orders are absolutely and implicitly obeyed. In order to enforce sanitary discipline, the speaker contended, there should be at least one deputy surgeon-general for every division of 20,000 men, as well as an increase of officers and men in the medical department in proportion to the size of the army. The reorganization could be made at little expense, because most of it could be provided for in the reserve corps. That corps would be on the payrolls only in case of active service, and it would result in tremendous saving of life and of sickness in the emergency of war.

The doctor declared the army should have a department of sanitation, separate and apart from its hospital service—advance guards and scouts, he calls them, against disease. Another matter that in his opinion should receive attention is a provision for a separate transport system, by which he means that all transportation requisite for the Medical Department should be made under its exclusive control. Finally, he claims the Medical Department should have proper authority over the Commissary Department, at least to the extent of the veto power.

"Surely," he exclaimed, "as our soldiers, who are citizens, are the best in the world, they should have provision for their health and their lives inferior to none in the world. If we do not surpass other nations in our zeal for their welfare, we should be ashamed. Pecuniary consideration is insignificant; but from this lower point of view it will prove that the increase to that of the most liberal nation will result in not only saving many lives, but in lessening the suffering and actually in diminution of expense. The appeal to the American's pocket should be the last made, but sometimes it is not the least effective."

Farming stands for individualism as distinguished from collectivism. Farming enterprises will be more and more amalgamated and capitalized, but they can never be syndicated and monopolized to the same extent as many other enterprises. How best to preserve and direct this democratic individualism of the open country is one of the greatest questions now confronting us.

RADIOGRAPHY IN ARMIES IN THE FIELD.

The applications of radiography to medicine and surgery are now very common in hospitals, but the extending of their use has never been tried to field hospitals until recently because of the fragile nature of the material and the amount of space required for a sufficiently powerful source of electricity. The fact will be recognized, nevertheless, that if it has been possible for radiography to render some service in medicine, it is especially in surgery that it should be utilized for the examination of fractures and a search for projectiles in the human body; and there is no place in which cases of this kind are more liable to be met with than in field hospitals. Nevertheless, this has been the only circumstance under which radiography has been considered as impossible. Such, however, owing to the ingenious combination recently constructed by the Gaiffe and Panhard-Levassor establishment, will no longer be the case in the future.

The system consists of an automobile 13 feet in length and 6 in width to the end of the axle journals, and provided with a 10-horse-power gasoline motor. The wheels, which are 36 inches in diameter, are provided with compound pneumatic tires. The room in the body of the car is 6.5 feet in length by 3.75 in width and contains all the apparatus. The total weight in running order is 6,160 pounds, the maximum speed, on a level, may reach 15 miles an hour, and hills may be climbed at a speed of 3 miles as a minimum. The material contained in the chamber was specially elaborated by MM. d'Arsonval and Gaiffe in such a way as to operate without accumulators or interrupter, two accessories that are delicate even in a stationary installation.

The system of throwing into and out of gear permits, when the vehicle is at a standstill, of utilizing the motor for actuating a dynamo, *D* (Fig. 1), placed under the seat of the motor car, and the armature of which, on the one hand, generates the continuous current necessary for the maintenance of the magnetic field, and, on the other, the alternating current designed for actuating the radiographic apparatus.

All the switches, rheostats, etc., for regulating the dynamo and the radiographic apparatus are mounted upon a panel in the chamber (Fig. 2, No. 1), and the radiographic apparatus itself is contained in a case (Fig. 2, No. 2) which is isolated in such a way that the vibrations of the vehicle shall not injure them. This case is mounted upon a strong floor crossbraced by a T-iron resting upon the chassis of the vehicle through the intermedium of large rubber buffers, and an analogous arrangement secures the box to the side of the body.

This box contains (1) a transformer, *B* (Fig. 2, No. 3) with closed magnetic circuit serving to increase the alternating tension of the dynamo in order to bring it to the maximum of efficient volts; (2) glass plate condensers, *C*, and liquid resistances, *H*, that assure the electric protection of the transformer against return waves, and serve to limit the flux of X-rays.

Upon the upper part of the box are fixed the terminals at which are established the connections of the X-ray tubes. As the current produced is an alternating one, there is connected at *S*, between these two points, a set of Villard valves, the object of which is to absorb one of the waves. In a box are found all the accessories necessary, such as the platino-cyanide screens for radioscopic examination and all the spare parts that may prove useful.

Since the examination of the wounded can be made only in the dark, there are tents provided which, by means of numbered frames, can be set up quickly back of the automobile in order to form a dark chamber for the surgeon and his patient. The hospital steward takes his seat in the vehicle, where he has within reach of his hand all the regulating apparatus. The X-ray tube is placed upon a support having a universal joint, and, under such circumstances, a radioscopic examination can be made as easily as in a hospital. If it is desired to do radiographing, everything necessary for that purpose is right at hand—frames, plates, trays, a red light, etc. A ten-gallon tank of water designed for photographic operations is placed at the upper part of the vehicle body, which, having been closed, is capable of serving as a dark room; but it is evident that in actual campaign work such a use of it would be exceptional.

During the great maneuvers of the East in September, 1904, Surgeon-Major Jacob, associate professor at the School of Application of Military Medicine of Val-de-Grâce, experimented with this automobile and submitted it to some very severe tests. He traveled nearly 1,800 miles over all the roads which in time of war would have to be traversed by the field hospital wagons. Every day, either along the route, or upon reaching a station, the machine was used for two or three hours for radiographic purposes, and in every case it was found that the apparatus operated perfectly.

After so conclusive an experiment, it is to be presumed that the material prescribed for field hospitals will be completed by the ingenious radiographic automobile devised by MM. Gaiffe and d'Arsonval, and the more so in that it can very well be utilized also for wireless telegraphy. But it is destined likewise to render services in time of peace, as has been remarked by the chief veterinary surgeon who represented France at the congress of army surgeons recently held at the St. Louis Exhibition.

In fact, small localities are entirely destitute of any means of performing radioscopic work, and if it is necessary to make investigations in this line upon a wounded person, the idea has to be given up.

It would suffice that in the center of each department there should be installed one of these machines that the surgeons of each locality might call to their aid in a case of urgency. The material would thus be

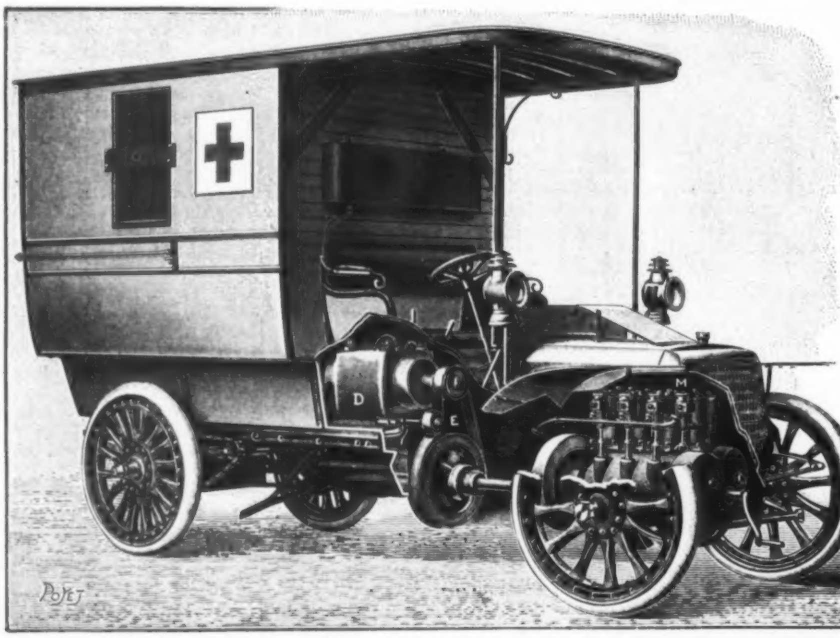


FIG. 1.—THE GAIFFE-PANHARD RADIOGRAPHIC CARRIAGE EMPLOYED IN THE GREAT MANEUVERS OF THE EAST IN 1904.

M. Motor. E. Starting gear of the dynamo. D. Dynamo.

FIG. 2.—1. REAR VIEW OF THE CARRIAGE.

D. Dynamo. C. Condenser. H. Liquid resistances. S. Villard valves. 2. Details of the condensers and resistances. 3. High-tension transformer.

kept in a proper state of operation, and, in case of war, might be used for hospital purposes in the field.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

A NOTEWORTHY COAL-HANDLING PLANT.

By J. A. MCINTYRE.

UP in the Lake Districts, where the season of open navigation lasts but a few months of the year, the problem of handling coal for current needs and storing a sufficient quantity to meet requirements during the months when coal cannot be transported, is one of great importance.

Nearly all the coal used is brought by water, the total tonnage being of great magnitude, and the buildings for the proper storage of it covering greater areas than can be found in any other part of the world.

The boats engaged in this trade are usually of large carrying capacity, and as the time they can be employed is short, economy is only attainable when means are available for rapidly unloading. The machinery employed for this purpose, therefore, is the best obtainable, and the equipment for reclaiming the stored coal is ample and convenient.

The Calumet and Hecla Mining Company, at South Lake Linden, Mich., has the most complete modern coal-handling machinery equipment and coal storage in the Lake Districts. The coal storage covers an area of five acres, and includes two sheds, each holding about 300,000 tons. During the working months the supply for current use is drawn from one shed, the other being kept filled for emergencies, such as strikes, tie-ups on the railroad, or any combination of circumstances which might bring about a coal famine. When the season closes both sheds are full, the storage containing sufficient coal to supply during the remaining months the copper mines, blast furnaces, smelting works, etc., controlled by the company in the district.

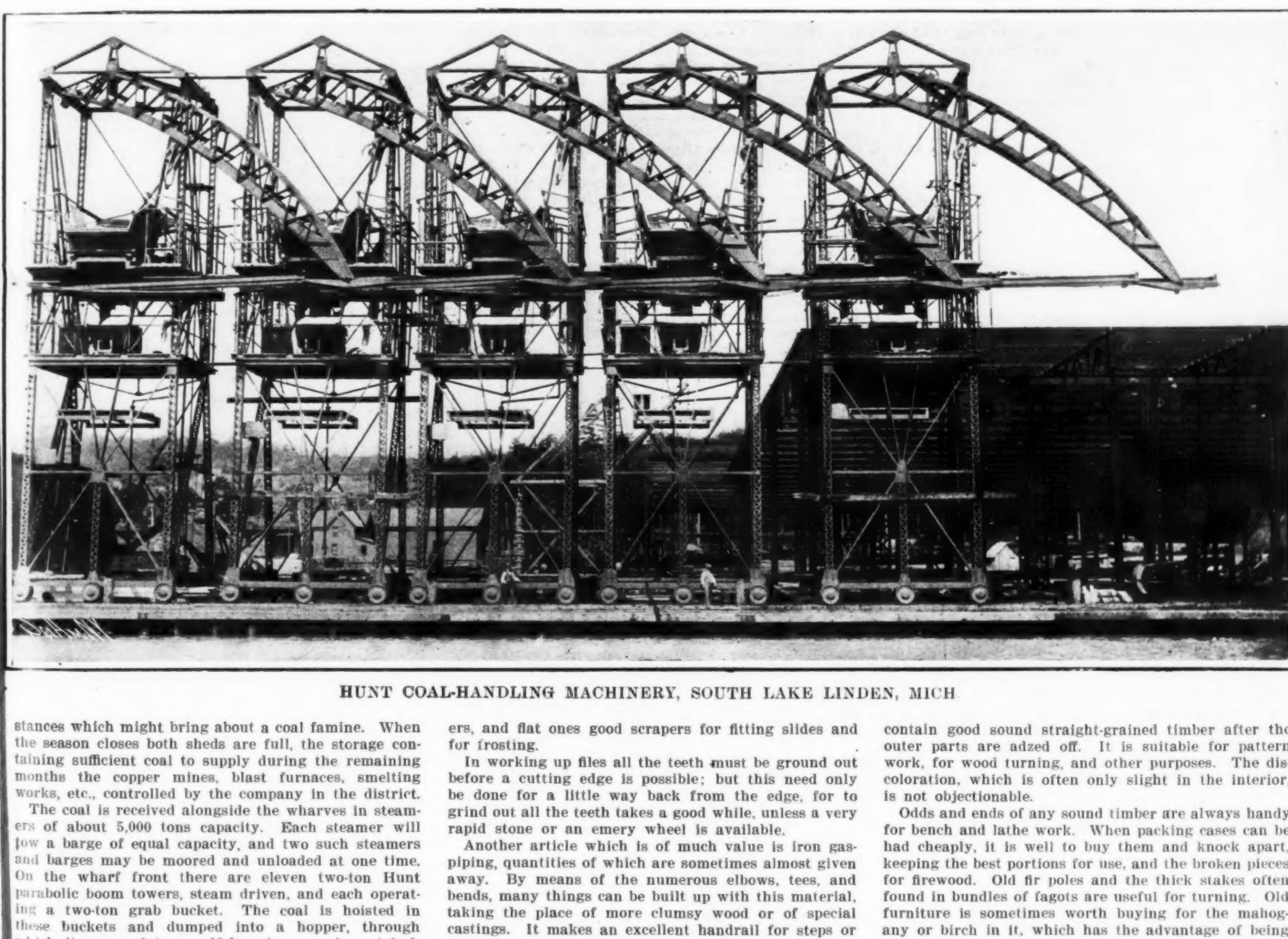
The coal is received alongside the wharves in steamers of about 5,000 tons capacity. Each steamer will tow a barge of equal capacity, and two such steamers and barges may be moored and unloaded at one time. On the wharf front there are eleven two-ton Hunt parabolic boom towers, steam driven, and each operating a two-ton grab bucket. The coal is hoisted in these buckets and dumped into a hopper, through which it passes into a self-dumping car, is weighed, and sent down on the automatic railway tracks and dumped into the coal storage.

Coal is piled to a height of twenty-two feet in the coal storage buildings, the floors of which are fitted with air ducts and ventilators, and the steel columns supporting the roof of the building also being equipped with perforated plates for ventilation. The roof trusses and purlins are of steel, and the roof of white pine covered with galvanized corrugated iron, felted and tarred, with a pitch of 3 per cent toward the rear. These coal storage buildings are 325 feet deep and about 750 feet long.

The coal is reclaimed from the storage sheds by a steam shovel, operating on a standard-gage track. The shovel closes on the coal, hoists and dumps it into cars, which are drawn to the different points of consumption over the Hecla and Torch railways, owned by the company.

The labor charges for trimming in the vessel and for operating the machinery have by the means described been reduced below anything heretofore accomplished in handling coal in the Lake Districts, and it is stated that more coal is handled per man employed than in any other place.

The wharf is heavily built of timber; the towers are steel structures movable on wheels; and the storage buildings and trestles are of steel on concrete foundations. The experience since these structures have been built fully justifies the Calumet and Hecla Mining Company's determination to build only in the most substantial way.



HUNT COAL-HANDLING MACHINERY, SOUTH LAKE LINDEN, MICH.

UTILIZING UNCONSIDERED TRIFLES.

MANY articles are wasted, after they have seen their legitimate turn of service, which might be turned to account in new duties. Nature wastes nothing; man is extravagant. The pinch of penury often has the effect of directing attention to articles that can be utilized with saving to the pocket.

The value of a worn-out file is seldom appreciated fully. Among tools that can be made from these are the following: Turning tools, scrapes, and burnishers, while the steel as such can be utilized by forging down for almost any articles. The turning tools include scrapes chiefly, being made from flat files. As the steel costs nothing, one can make these as wanted for finishing curves, fresh tools for different radii from flat to quick, and convex and concave, and for turning wood and metal, the only difference being in the degree of keenness of angle. Another service is that of side tools and diamond points, which are in constant request for wood-turning as in boring out recesses turned on work between centers, for which both right and left-hand tools are required. Gravers can be made of triangular files, and round-nosed roughing tools from square ones. Triangular files make excellent burnishers, and flat ones good scrapers for fitting slides and for frosting.

In working up files all the teeth must be ground out before a cutting edge is possible; but this need only be done for a little way back from the edge, for to grind out all the teeth takes a good while, unless a very rapid stone or an emery wheel is available.

Another article which is of much value is iron gas-piping, quantities of which are sometimes almost given away. By means of the numerous elbows, tees, and bends, many things can be built up with this material, taking the place of more clumsy wood or of special castings. It makes an excellent handrail for steps or fencing for gardens, or fowl runs by stretching wire netting over it. It can be made up with elbows into supports for broad shelves or tables, or benches in conservatory or potting shed, being let into wall and floor.

Old steel bull-headed rails are utilized by engineers in some structures. Amateurs can find a use for them as posts for fencing, the main uprights for sheds of all kinds, and as posts for gateways.

I have picked up many articles of utility from light foundry scrap. This often includes small belt and grooved pulleys, and toothed wheels, both spurs and bevels, spindles, levers, the frames of sewing machines, many of which are not damaged in the least. If these are carefully husbanded, they are sure to come in useful after the proverbial seven years. When such things have to be bought or patterns made for them the value of such a hoard is appreciated. And even though it may not be always possible to pick out any article of exactly the size wanted, something near enough may be found, and other parts modified to suit. A wheel bore, for instance, is not of cardinal importance, nor the exact size of a spindle or of a pulley or toothed wheel. A collection of levers will often save troublesome forging. If access is not readily had to a scrap-heap, the marine-store dealers in manufacturing towns may often be visited with advantage. Old sewing machine legs make useful and ornamental supports for a table carrying buffing emery wheels or a light bench lathe, or a light workbench or a table for odds and ends.

Much of broken and worn stuff from the bench need not be thrown away. If a paring gouge breaks, grind it outside and so turn it into a firmer gouge. If a paring chisel breaks, grind it afresh and use it for facing in the lathe. Worn out centerbits can be ground to form screwdriver bits for the brace. Oilstones, when worn down, can be turned into gouge slips. Broken pieces of grindstones are of use in topping circular saws. A grindstone worn down to a small diameter can be turned in the lathe into grooves for grinding paring gouges.

Springs of all kinds should be treasured for future use, whether of flat steel or wire. Any pieces of spring steel are valuable. Broken pieces of band-saw blades are valuable for making timber scrapes from. Pieces of suitable dimensions are nicked and broken off, and then ground to decent shapes and sizes suitable for the scrapes required.

The numerous canned goods sold result in quantities of tins being thrown away into the dustbin. Many of the best of these might be saved and utilized as paint cans, and receptacles for nails, screws, staples, and other stores. The edges will be filed round evenly, and the arris taken off, two holes drilled in opposite sides of the rim and a wire handle bent round and fitted. A couple of coats of paint will preserve from rusting.

Railway sleepers, often sold for firewood, frequently contain good sound straight-grained timber after the outer parts are adzed off. It is suitable for pattern work, for wood turning, and other purposes. The discoloration, which is often only slight in the interior, is not objectionable.

Odds and ends of any sound timber are always handy for bench and lathe work. When packing cases can be had cheaply, it is well to buy them and knock apart, keeping the best portions for use, and the broken pieces for firewood. Old fir poles and the thick stakes often found in bundles of fagots are useful for turning. Old furniture is sometimes worth buying for the mahogany or birch in it, which has the advantage of being well seasoned. Old oak may be picked up at sales of builders' material.

Casks which have contained paraffin or wine are useful for making tubs for holding evergreens or rain-water. A good many of these can be utilized in this way. They are cut across the middle with a hand-saw, and dressed off neatly with a plane. The wood can be painted green and the bonds black. Center-bit holes must be bored in the bottom if for plants. Should the tubs be heavy, it is as well to attach iron or brass handles on the sides for lifting them about by. Some large German wine-casks have staves two inches thick, and make splendid vessels for holding water. Sherry casks are strong, so are burgundy casks from Australia.

Sheets of broken glass need not be thrown away. With a sixpenny glass-cutter they can be cut into smaller rectangles and used for glazing garden frames, and for laying on flower-pots and seed pans and young plants. Never throw away cracked and damaged flower-pots. Broken up, they form the necessary stratum at the bottom of other flower-pots, tubs, and boxes for plants.

Sometimes there comes a clearing of old books. The

dealers give next to nothing for them; but some of the strongest bindings can be utilized as cases for pamphlets and magazines that are not valuable enough for binding up. A label can be pasted on the back, having the contents written plainly, and the papers can be retained with a large elastic band.

Sometimes in the course of business one gets exceptionally large canvas-lined envelopes or bags. I preserve these for newspaper cuttings, writing in large letters the contents of the package on a piece of paper pasted over the address.—English Mechanic and World of Science.

THE RECEPTION AND UTILIZATION OF ENERGY BY A GREEN LEAF.*

THE discussion of the thermal relations of a leaf to its surroundings will be simplified if we first consider the case of a leaf when it is shielded from solar radiation. We will assume that a detached leaf, freely supplied with water, is placed in an inclosure the walls of which are non-reflective and are maintained, along with the inclosed air, at a perfectly uniform temperature t. We will further assume that the air is saturated with water-vapor.

Under these conditions the system would remain in thermal equilibrium if it were not for the respiratory processes going on within the leaf cells. These are exothermic in their final result so that the state of complete thermal equilibrium can be attained only when the temperature of the leaf has risen to a point t', somewhat higher than t. The magnitude of the difference $t' - t$, representing the maximal thermometric disturbance between the leaf and its surroundings, will depend on three main factors:

(1) On the rate of evolution of the heat of respiration.

(2) On the rate at which this heat is dissipated by the thermal emissivity of the leaf-surface, and,

(3) On the magnitude of the slight rise of partial pressure of the water-vapor in the interspaces of the leaf, which gives rise to a certain amount of diffusion of water-vapor through the stomata.

The rate of evolution of the heat of respiration can be deduced with sufficient exactness from the amount of carbon dioxide liberated per unit area of the leaf-lamina in unit of time, since there is evidence that the carbon dioxide proceeds from the oxidation of a carbohydrate with a heat of combustion which cannot be far removed from 3,760 calories per gramme. Taking the concrete example of a leaf of the sunflower respiring at the rate of 0.70 cubic centimeter of carbon dioxide per square decimeter per hour, it can be shown that the heat of respiration in this case amounts to about 0.00582 calorie per square centimeter of leaf-lamina per minute. From the known weight of a square centimeter of the leaf-lamina, and its specific heat, this spontaneous liberation of energy within the leaf might conceivably raise its temperature through 0.033 deg. C. per minute, provided there were no simultaneous losses due to radiation, conduction, and convection of the surrounding air, and internal vaporization of water. All these sources of loss, of course, become operative immediately the temperature of the leaf exceeds that of its surroundings. We shall see presently that the thermal emissivity of this leaf in still air is 0.015 calorie per square centimeter of leaf-surface per minute, for a difference of temperature of 1 deg. C. between the leaf and its surroundings, so that the temperature of the leaf under the conditions postulated cannot exceed that of its surroundings by more than

$$0.00582/2 \times 0.015 = 0.019 \text{ deg. C.}$$

But this is assuming that transpiration has been in abeyance, which is certainly not the case, so that this small temperature difference of 0.019 deg. C. will be still further reduced.

The main point which I wish to bring out here is that the thermometric disturbances due to the processes of respiration are very small, so small, in fact, that they may be neglected in considering the large disturbances induced by other causes.

Let us now suppose our leaf to be placed under the same conditions as before, but in air which is not fully saturated with aqueous vapor for the temperature t.

The conditions are manifestly unstable owing to the excess of the partial pressure of the water-vapor in the saturated air of the interspaces of the leaf over that of the vapor in the unsaturated air outside.

The diffusion-potential thus set up will result in water-vapor passing outward through the stomata, and the temperature of the leaf will fall. This fall will continue until the gradient of temperature between the surroundings and the leaf is sufficiently steep to allow energy to flow into the leaf from without at a rate just sufficient to produce the work of vaporization, at which point a steady thermal state will be established which will remain constant so long as other conditions are unaltered. The leaf will then have assumed a temperature t', which in this case will be *lower* than that of its surroundings.

Now it is manifest that when this steady thermal condition has been attained, the amount of water vaporized per unit of area of the leaf in unit of time must be a measure of the energy flowing into the leaf for the gradient temperature represented by $t - t'$, and provided we determine the amount of water lost by the leaf, and the temperature difference between the leaf and its surroundings under the steady conditions, we have all the data necessary for finding the *coefficient of thermal emissivity* of the leaf-surface in absolute units, that is to say, the rate at which a leaf-surface will emit or absorb energy from its surroundings in still air for a difference of temperature of 1 deg. C.

Following out this idea, Dr. Wilson and I have successfully determined the constants of thermal emissivity for leaves of different kinds, both under "still-air" conditions and in air-currents of determinate velocity. The results are interesting from several points of view, since among other things they enable us to estimate the rate at which the excess of solar radiant energy falling on a leaf is dissipated by mere contact with the air moving at any ordinary wind-velocity, and they also give us, under certain conditions, a means of deducing the actual rate of transpiration from mere observations of temperature-differences.

Before proceeding to show more in detail the manner in which the thermal emissivity of a leaf is determined, we will turn for a moment to the magnitude of the difference of temperature between a leaf and its surroundings which may be expected from a given rate of transpiration. We will assume that the leaf of a sunflower, transpiring into the unsaturated air of the inclosure, when the steady thermal condition is attained, is losing water at the rate of 0.5 gramme per square decimeter per hour, or 0.0000833 gramme per square centimeter per minute.

The heat required to vaporize this amount of water at 20 deg. C. is $0.0000833 \times 592.6 = 0.04938$ calorie, which, on the theory of exchanges, must represent the amount of energy entering and leaving a square centimeter of the leaf-lamina per minute. The thermal emissivity of this leaf is 0.015 calorie per square centimeter of leaf-*surface* per minute, for a temperature gradient of 1 deg. C., so that the temperature difference $t - t'$ will be represented by

$$0.04938/2 \times 0.015 = 1.64 \text{ deg. C.}$$

For the simultaneous determination of the temperature difference $t - t'$ and the amount of water transpired, we employed two differential platinum-resistance thermometers each consisting of about 2.4 meters of fine wire arranged in a mica and ebonite plate so as to form a flat grid, against the two sides of which two similar leaves were lightly pressed and held in position by ebonite frames furnished with cross-threads of silk. The two leaf-laminæ were thus in close apposition to the resistance-coils, which were favorably placed for rapidly acquiring the mean temperature of the leaves, which were supplied with water from two small tubes attached to the frames. A definite area of leaf-surface was exposed, amounting in each case to 139.4 square centimeters. The loss of the water of transpiration was determined by weighing the apparatus at suitable intervals.

As examples of the extent to which the thermal emissivities of leaves of various plants differ, the following may be given. They represent the emissivity under conditions of still air:

Thermal Emissivity of Leaves of Various Species of Plants, under Still-air Conditions.

Species of Plant.	Thermal emissivity in calories per sq. cm. of leaf-surface for a 1° C. excess of temperature. Per minute.	Per second.
Liriodendron tulipifera (a).....	0.0119	0.000199
Liriodendron tulipifera (b).....	0.0127	0.000212
Helianthus multiflorus	0.0150	0.000249
Tropoeolum majus	0.0142	0.000237
Tilia europoea	0.0159	0.000266

Under ordinary outdoor conditions we never have to deal with perfectly still air, and the inquiry had therefore to be extended to the influence of *moving* air currents on the thermal emissivity of leaves.

This was investigated by observing the differential temperature and differential transpiration when the two pairs of leaves were placed in a shaft through which a current of air was passed having a definite and steady velocity. The effect of the cooling or heating due to the air is a linear function of the velocity, the coefficient of thermal emissivity of the leaf-surface increasing at the rate of 0.017 calorie per square centimeter per minute for an increased velocity of the air current of 100 meters per minute. This effect of moving air in dissipating the excess of radiant energy falling on a leaf is a very important fact in the economy of some plants in which transpiration is reduced to a minimum, and it is one of nature's means for preventing the rise of temperature in strongly insolated plants from reaching a dangerous point.

We must now turn our attention to the thermal relations of a leaf to its surroundings when it is receiving direct solar radiation, and here again, for the purpose of simplifying my argument, I must ask you to imagine an ideal set of conditions under which a healthy leaf, well supplied with water, is exposed to sunlight of constant intensity, and that there is no variation in the temperature, humidity, or degree of movement of the surrounding air, or in the dimensions of the leaf stomata.

As in the previous case, a state of thermal equilibrium will be speedily established between the leaf and its environment, when the simultaneous loss and gain of energy will just balance.

When this condition is attained, let R represent the total radiation falling on one square centimeter of the leaf in one minute, and, further, let the "coefficient of absorption" of the leaf for this radiation be represented by a; then Ra will represent the radiant energy absorbed per square centimeter of leaf-lamina per minute.

At this stage it is of some interest to give absolute values to R and a in order to see what would be the thermometric effect produced on a leaf by ordinary sunshine in default of there being some ready means of dissipating the absorbed energy.

If we denote the mass of a square centimeter of the leaf-lamina by m, and its specific heat by s, then on the above assumption the rise of temperature of the lamina per minute will be represented by Ra/ms.

Let $R = 0.8$ calorie per square centimeter per minute, which represents the intensity of ordinary summer sunshine in these latitudes.

Let a, the coefficient of absorption, be 0.78, a value which is determinable by a method presently to be described; further, let the mass, m, of a square centimeter of leaf be 0.020 gramme, and its specific heat $s = 0.879$, then the rise of temperature of the leaf under the conditions postulated will be at the rate of

$$0.8 \times 0.78/0.02 \times 0.879 = 35.4 \text{ deg. C. per minute,}$$

a result which would be speedily fatal to the leaf.

The dissipation of the absorbed energy necessary to keep the temperature of the leaf within working limits is provided for, on the one hand, by the internal work of the leaf, consisting mainly of the vaporization of water, and to a less extent of the endothermic process of photosynthesis, and on the other hand by the losses due to thermal emissivity, which even in still air are considerable, and may assume large dimensions if the air is in movement.

First, as regards the energy used in internal work, that portion which produces the vaporization of water, and which I will denote by W, is determinable from the weight of water lost by a given area of the leaf in a given time, and from the known latent heat of water-vapor. On the other hand, the amount of the absorbed energy which is used up in the photosynthetic process, and which I will denote by w, is deducible from the actual amount of carbon dioxide which enters the leaf, on the legitimate assumption that the synthesized product is a carbohydrate, the heat of formation of which is approximately known.

The generalized form of the thermal equation of a leaf which is receiving solar radiation, and has acquired a state of thermal equilibrium, may therefore be represented by $Ra = (W + w) \pm r$.

When Ra is greater than $W + w$, that is to say, when the energy absorbed by the leaf in a given time is more than sufficient to perform the whole of the internal work, r is a positive quantity, and represents in absolute units the sum of the losses due to radiation and convective cooling, and it is the only portion of R which can produce a rise of temperature in the leaf.

Provided we know the thermal emissivity of the particular leaf which we are using, the actual rise of temperature of the leaf-lamina above its surroundings can be determined from r; for if e is taken to represent the emissivity, then the temperature difference between the leaf and its environment, that is to say, $t' - t$, will be $r/2e$.

On the other hand, when Ra is less than $W + w$, that is to say, when the absorbed radiant energy is insufficient to perform the whole of the internal work, r is a negative quantity, and the excess amount of energy requisite to perform the internal work must be drawn from the surroundings of the leaf; in other words, when thermal equilibrium is established the temperature of the leaf under these conditions must be *below* that of its surroundings. Here again, however, the thermometric difference expressed by $t - t'$ will be $r/2e$.

The true measure of the photosynthetic work effected by suitable radiation is, strictly speaking, not given exactly by the amount of atmospheric carbon dioxide absorbed by the leaf, but by this amount *plus* the small amount of carbon dioxide which would have been evolved by respiration if photosynthesis had been in abeyance. This is a correction which has to be taken into account in certain special cases, but it does not affect the generalized thermal equation I have given, since the heat of respiration is opposite in sign to that of the heat of re-formation of the carbohydrate, and these values, representing a concurrent gain and loss of energy by the leaf, must exactly balance each other if the carbohydrates standing at the two ends of the reversed process are identical, and if they are not identical the difference in their thermal relations must be so small as to be inappreciable.

The coefficient of absorption, as might be expected, varies considerably with leaves of different species of plants, as shown in the following table, and there are also small individual differences in leaves of the same plant.

Coefficients of Absorption (a) and Transmission ($1 - a$) of the Radiant Energy of Sunlight for Leaves.

Plant.	Coefficient of absorption (a)	Coefficient of transmission ($1-a$)
Helianthus annuus........	0.686	0.314
Polygonum Weyrichii......	0.647	0.353
Polygonum sachalinense...	0.691	0.309
Petasites officinalis........	0.728	0.272
Silphium terebrinthaceum.	0.699	0.391
Arctium majus	0.728	0.272
Verbascum olympicum.....	0.758	0.242
Senecio grandifolius.......	0.774	0.226

In the generalized thermal equation the value w, representing the amount of energy expended in photosynthesis, measures the effective internal work of a useful and constructive kind, for the due performance of which the leaf may be said to exist, and the relation which this bears to the total energy flowing into the leaf gives an estimate of the true *economic coefficient* when the leaf is regarded as a thermodynamic engine.

In deducing the amount of energy used up in the photosynthetic work from the amount of carbon dioxide absorbed by the leaf, we have assumed, as we are entitled to do, that the product of assimilation is a car

* Abstract of the Bakerian lecture, delivered at the Royal Society, March 23, by Dr. Horace T. Brown, F.R.S.

bohydrate. If the particular form of carbohydrate is known, the amount which corresponds to a definite mass of carbon dioxide absorbed by the leaf is of course determinable; and, further, the energy used up in synthesizing this amount of carbohydrate will be represented by its heat of combustion.

No sensible error will be introduced into this calculation by selecting one of the carbohydrates existing in a leaf in preference to another. We have based our calculations on the assumption that we have to deal with a *hexose* having a heat of combustion of 3,760 calories per gramme. On this basis the assimilation of 1 cubic centimeter of carbon dioxide corresponds to the absorption of 5.02 water-gramme-units of energy; hence by multiplying this value by the number of cubic centimeters of carbon dioxide assimilated per unit area of leaf in unit of time we obtain the value of w for the generalized thermal equation.

We found, among other things, that the actual rate of photosynthesis induced in a leaf which is bathed by ordinary air remains practically constant within very wide limits of insolation. This is due to the fact that the special rays which produce photosynthesis are present in solar radiation of even moderate intensity far in excess of the demands of the assimilatory centers for dealing with the atmospheric carbon dioxide which reaches them by the process of diffusion. The proof of this is afforded in the first place by the enhanced assimilatory effect which is produced by increasing the partial pressure of the carbon dioxide in the air surrounding the leaf, and, secondly, by the fact that we can reduce the intensity of ordinary summer sunlight to a very considerable extent by using revolving radial-sectors placed in front of the leaf, without sensibly affecting the rate of photosynthesis.

It follows from this that the *economic coefficient* of the leaf, which is the ratio of the energy utilized for photosynthesis to the total radiation falling on the leaf, must necessarily increase with diminished insolation, until a point is reached at which practically the whole of the special rays which are active in producing assimilation are utilized. At this point the economic coefficient of the leaf must be at a maximum with respect to a given partial pressure of carbon dioxide; in other words, the leaf regarded as a thermodynamic engine is then working with the least possible waste of energy.

In order to illustrate this I will take the case of a leaf under the influence of moderate sunlight of an intensity of 0.50 calorie per square centimeter per minute, and assimilating at the rate of 2.07 cubic centimeters of carbon dioxide per square decimeter per hour. This corresponds to an economic coefficient of 0.34 per cent. On gradually diminishing by suitable means the radiation falling on the leaf, it was found possible to reduce it to 1-12 of the original amount before any appreciable difference in the rate of assimilation was observed. The economic coefficient was thereby raised to the maximum of a little more than 4 per cent. This 4 per cent will also approximately measure the proportion of the special grade of energy in the original radiation which is capable of inducing photosynthesis.

It is, however, only under very exceptional conditions that we can obtain anything like this maximal "duty" from the leaf.

The following table, showing the results with leaves of *Polygonum Weyrichii* under varying degrees of insolation, will give some idea of the values of the economic coefficient ordinarily met with:

The Economic Coefficient of Leaves of *Polygonum Weyrichii* under Various Degrees of Insolation.

Radiant energy falling on 1 sq. cm. of leaf per minute, in calories R	Economic coefficient $w/R \times 100$
0.612	0.42
0.194	1.59
0.150	1.66
0.143	1.32

Turning once more to the generalized thermal equation

$$Ra = (W + w) \pm r$$

we must not lose sight of the fact that this represents a set of conditions in which all the determining factors, both internal and external, remain constant for a sufficient time to allow of the attainment of steady *thermal equilibrium* between the leaf and its surroundings.

In practice this ideal state is never attainable. In the first place the incidence of solar radiation is subject to rapid oscillations of considerable magnitude, even under the most fair-weather conditions, and every variation of this kind necessarily alters the value of Ra, the energy absorbed by the leaf, and will produce its effect on r, on which the temperature of the leaf depends. This, again, will influence the amount of water-vaporization, and so affect the value of W. In addition to this, complex disturbances may be introduced by the automatic opening or closing of the stomata, by variations in the hygrometric state of the air, and, perhaps more important than all, by changes in the velocity of the air blowing over the leaf, which will alter its rate of emission.

With all these varying factors acting and reacting on each other in endless complexity, it will be readily understood that under natural open-air conditions the thermal relation of a leaf to its surroundings must be undergoing constant re-adjustment, and that the point of thermal equilibrium must change from moment to moment with every passing cloud, with every gust of wind, and with each change of inclination of the leaf-lamina to the incident radiation.

In the absence of means for instantaneously recording all these variations, it is manifestly impossible to determine the thermal conditions for any particular moment of time, and perhaps there would be no special advantage in doing this even if it were possible. It is, however, quite practicable to determine the *mean* values of the varying factors and the average effects which they produce during a period of time, say of several hours' duration, and we can then introduce these mean values into our equation, which will thus give us all the information we require.

I will now proceed to illustrate the application of these general principles by the consideration of a few concrete examples.

The first is that of a leaf of the sunflower, in which the experiment lasted for about four hours. The results are expressed in water-gramme-units (calories), and the units of area and of time are the square centimeter and the minute respectively.

The conditions were such that the total solar radiation absorbed by the leaf was in excess of that required to perform the internal work of transpiration and photo-synthesis; in other words, Ra was greater than $W + w$. Hence r was a positive quantity, and the temperature of the leaf was consequently somewhat higher than that of its environment.

Case A.—Leaf of *Helianthus annuus.*

Total solar radiation .... $R = 0.2569$ calorie.
Coefficient of absorption, $a = 0.686$,
∴ solar energy intercepted..... $Ra = 0.1762$ calorie.
Water vaporized = 0.000209 gramme, ∴ W, the internal work of vaporization = 0.000209 × 592.6 .... 0.1243 calorie.
Rate of photosynthesis = 0.000355 cubic centimeters CO_2, hence w, absorption of energy due to assimilation = 0.000355 × 5.02 =..................... 0.0017 calorie.

$$Ra = W + w + r$$
$$0.1762 = 0.1243 + 0.0017 + 0.0502$$

Velocity of wind = 25.7 kilometers per hour = 428 meters per minute.
Thermal emissivity of leaf-surface in still air = 0.0150 calories.
Thermal emissivity (e) in air of velocity of 428 meters per minute = 0.0150 + 0.00017 × 428 = 0.0577 calorie.
Hence mean temperature of leaf *above* that of surroundings = $r/2e$ = 0.0502 × 0.0577 = 0.43 deg. C.

The disposal of the incident radiant energy deduced from these data is given in the next table, the total incident energy R being taken at 100.

Case A.—Disposal of Incident Solar Energy by Leaf of *Helianthus annuus.*

w	Energy used for photosynthesis.	0.66	
W	Energy used for transpiration...	48.39	
$W + w$	Total energy expended in internal work		.05
$R - Ra$	Solar energy transmitted by leaf......		31.40
r	Energy lost by thermal emission......		19.55
			100.00

We will now consider another case in which the facilities for the performance of the internal work of vaporization of water were more than sufficient to use up the whole of the direct solar radiation absorbed by the leaf, i.e. Ra was less than $W + w$.

Such conditions are afforded by fully opened stomata, high temperature, and a low degree of humidity of the air. The leaves used were again those of the sunflower, but in this case one-half of the solar radiation was intercepted by the revolving sectors.

Case B.—*Helianthus annuus.*

Solar radiation incident on leaf R.... = 0.2746 calorie
Coefficient of absorption, $a = 0.686$, ∴ solar energy intercepted, Ra....... = 0.1884 calorie.
Water vaporized = 0.000618 gramme, ∴ W, the internal work of vaporization, = 0.000618 × 592.6................ = 0.3668 calorie.
Rate of photosynthesis = 0.000657 cubic centimeters CO_2, hence w, absorption of energy due to assimilation .... = 0.0033 calorie.

$$Ra = (W + w) - r$$
$$0.1884 = 0.3668 + 0.0033 - 0.1817$$

Velocity of wind = 12 kilometers per hour = 200 meters per minute.
Thermal emissivity of leaf-surface in air of this velocity = 0.015 + 200 × 0.00017 = 0.0490 calorie.
Hence mean temperature of leaf below that of surroundings = $r/2e$ = 0.1817/0.0490 = 1.84 deg. C.

Case B.—Disposal of Energy Received by Leaf from Solar Radiation and from Heat Conveyed from Surroundings.

$R + r = 100.$

w	Energy used for photosynthesis.	0.72	
W	Energy used for transpiration..	80.38	
$W + w$	Total energy expended in internal work		81.10
$R - Ra$	Solar energy transmitted by leaf......		18.90
			100.00

During the time at my disposal I have only been able to give a brief outline of the general principles underlying an attempt to deal with the main functions of a foliage leaf from the point of view of its energetics, and I must refer those of my hearers who are specially interested in the subject to the papers themselves for the further elaboration of the argument and for the facts on which it is based. I trust, however, that this short account of the work may be sufficient to indicate that we have experimental means of studying quantitatively the reception of various grades of energy by a leaf, the proportion of this which is utilized for the two main kinds of internal work, and also the thermal relations of a leaf to its surroundings under given conditions.

In conclusion, I wish to anticipate a possible objection which may be raised on theoretical grounds to some of the views I have expressed. I have assumed throughout that the second law of thermodynamics is applicable to the phenomena we have been discussing. The statement of that law by Lord Kelvin limits its application to "inanimate objects," and doubtless if the living elements of the leaf-cells possess any power of dealing with the individual molecules of the surrounding medium so as to select and utilize the kinetic energy of those which are moving faster than the "mean square speed," it may well happen that a leaf may be able to perform some kind of internal work without there being any difference of mean temperature between it and its surroundings. In this event the views I have put forward would doubtless require some slight revision, but I think we may well wait until this restriction of the second fundamental principle of thermodynamics has received some experimental support.

SIR OLIVER LODGE ON "THE CAUSE AND REMEDY FOR UNEMPLOYMENT."

READERS will be interested in the address delivered before the Social and Political Education League at University College on some social reforms by Sir Oliver Lodge. The necessary precursor of wise and effectual reform, said Sir Oliver, was knowledge—knowledge both wide and accurate of the state of society and of the conditions of action. To this end a long-continued and devoted study of the human problem as a branch of science was as necessary as was the intuitive and energetic zeal of the reformer. The art of government would not continue to be the one department of activity for which no training was supposed to be necessary. It seemed to him that many eminent humanists at the present time discriminated too completely between the study of man and the study of nature. The essential truth that we had to learn and grow accustomed to was that man was a part of nature, and the study of man divorced from the study of nature was bound to be one-sided and partial and incomplete.

After referring to the potency of education in improving the conditions of life, he expressed the view that the laws of inheritance would have to be considered some day. The idea that people might live without working, and yet without disgrace was responsible for much incompetence and some misery. It was good neither for the youth brought up in the idea nor for those whose labor had to supply him with what he demanded. All should have leisure, but none should be completely idle on pain of starvation or the disciplinary drill of prison.

But was there any class on which the hand of reform could be at once laid? He answered that there were two such classes.

He contended that hitherto in these two directions society had by no means risen to a sense of its power and its responsibility. It was too imbued with the idea of punishment, too faithless about efforts toward reformation and improvement. Paupers were the patients of society. In their present state they were useless, and they were very likely deserving of blame. Anyway, they had failed and they required help. They must be shown how to live, how to work, how to develop their faculties. To put them to a hopeless task, like oakum-picking or breaking stones, was to disgust them with labor. It was to give them things to do for which a machine was the proper agent. Why should society set upon them and try to crush them into hopelessness and rebellion? That was not the object for which we paid poor-rates. By placing the people on unreclaimed or unfertile land calling out for labor, under skilled supervision, they might, he believed, be made self-supporting before long. Whatever might be the case with paupers, concerning the criminal class he was perfectly certain we were doing wrong. We were seeking to punish, not to educate, stimulate, reform. Prisoners should be put under industrial conditions, and should be organized into useful members of society. Unless they were reformed they should not be set free. It was stupid to release them in order knowingly to reinforce the ranks of the criminal classes. Prisons should be reformatories, and sentences might be indefinite and contingent on reform.

But in order to be effective reformatories they must be humanely and wisely administered. If any trade union objected to the utilization of prison labor, and the production of useful commodities even for internal consumption, it should be made clear to them that the object of prison discipline was not, primarily, the manufacture of goods, but the reform and manufacture of human beings from the refuse of humanity—a kind of shoddy for the first time worthy of Divine manufacture. Nor did he believe that the trade union leaders would object to this if it were properly presented to them. To say that the army of workers was already overstocked was no answer. If it were, it was equivalent to throwing up the sponge and admitting that this planet could not support its present population. It was absurd to suppose that. It would be time enough to throw up the sponge in despair when a few centuries

of really intelligent study and unselfish legislation had been tried.

A beginning of the new state of things was being made. Municipal and socialistic enterprises were in the air. They were running the gantlet of criticism and suspicion, as all things had to do before they were purged of their dross. He maintained that never before was the outlook so hopeful; never were all classes so permeated by the spirit—not the phrases, but the essential spirit—of brotherhood and co-operation; never was there such universal recognition of the beauty of the spirit of real and vital Christianity, far above the differences and dogmas of the sects. With the extension of local self-government legislative progress might be more rapid. The best men would throw themselves into public service with more heart and energy than now, when, in an overloaded and centralized Assembly, progress was so slow and the machinery so old and cumbersome that the output was quite incomparable with the time and labor involved in getting it through.

STRANGE MAZES AND CHASMS IN MAMMOTH CAVE.

By Dr. Horace C. Hovey.

The Mammoth Cave is not one immense cavern, but a congeries of many caverns, whose walls or floors have worn through into each other. For the sake of convenience, certain familiar routes are fixed; but equally grand and beautiful halls and galleries are rarely seen, and the very existence of some of them would be forgotten were they not indicated on the cavern maps. As an instance of this, the discovery of two magnificent domes was recently reported to the writer, and names were given them; but on consulting my notes I found that I had visited them in 1878, and that they were on Blackall's map of 1870 as Olivia's Domes. Mr. Norman A. Parrish, an expert climber, made the discovery in 1904 that the standard map of Mammoth Cave errs in its location of Marion Avenue, which he reached by a short cut from Washington Hall; but this same correction was made by Blackall. He also explored what he regards as a new avenue, branching from Mary's Vineyard to the right, and to which he gives the name of the Grand Canyon. After going half a mile he came to a crossing of passages and a cleft six feet wide and forty feet deep. The guide, John Nelson, did not think it had ever been crossed. Safely leaping over it, they found no signs of previous exploration. (This chasm has since been explored by Nelson and Einbiglers.) They found a curious complex of upper and lower galleries, extremely beautiful, which they illuminated by Bengal lights, the effect being such as to seem to warrant the name above mentioned. They went a long distance, but did not reach the end of the canyon. They also explored several small avenues branching from Marion Avenue, one of which leads to a series of deep pits. I regard Mr. Parrish's work, done last year, as valuable, and do not doubt that he made a number of original discoveries.

The guides ascribe daring exploits to Robert Louis Stevenson, who never set foot on Kentucky soil. They also say that Stephenson's Avenue is named for him, although it has had that name for fully forty years. Inquiry was rewarded by finding that an English traveler, named F. J. Stephenson, visited Mammoth Cave in 1863, and wrote an account of what he saw in some letters to his mother in London. Through the kindness of Mr. Edward Valpy these interesting letters are now in my hands, with permission from the author to publish such parts as might have public interest. Of course, much of the narrative traverses ground already familiar to cave-hunters.

Stephenson's visit was in war times. Mr. Owsley, the landlord, though a unionist, was a slaveholder. Guerrillas confiscated his valuables, but his slaves were not taken, being hidden in caverns on the other side of Green River. Nick Brandsford, Stephenson's guide, was an ex-slave, who had bought his freedom by the sale of eyeless fish. A French guide, Frank de Mowbrand, also served him.

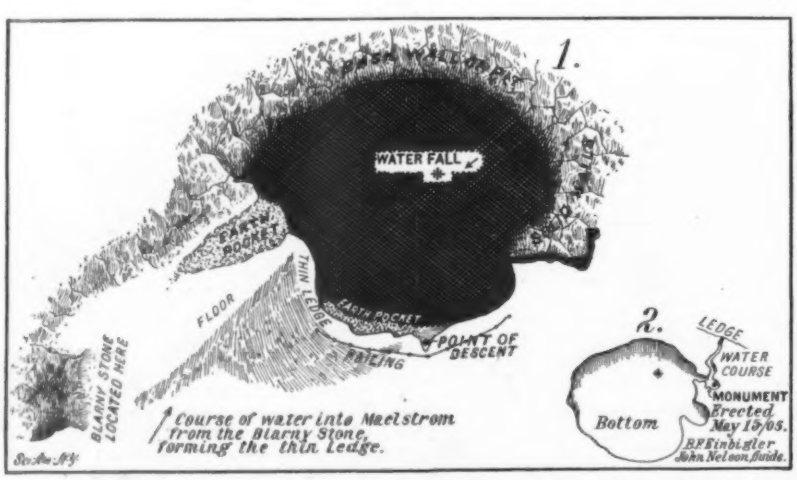
Visitors to Gorin's Dome find at the bottom a sluggish stream, on whose margin lies an old flatboat filled with sand. It was the rude craft in which Stephenson made one of the wildest voyages ever known. It was lowered by what is termed the "window" of the dome, after which he and his guide went down the well-like chasm known as Garvin's Pit. At the place of embarkation the arch was only eight inches above the water, and he had to lie flat on his back and push the boat along by his hands. As he advanced the tunnel widened, the roof lifted, the stream was deeper, and he could use his paddle.

JOHN M. NELSON, MAMMOTH CAVE GUIDE.

The guides had fastened a rope to the boat as a tether; but the solitary voyager cast this off, and passed beyond the reach of their voices. Presently he landed on a broad island, overhung by a dome with fine formations. After exploring this island, he took to his boat again, and passed many side branches, marking his course by signs on the walls, as a necessary precaution. After a while he came to a gloomy labyrinth of arches like inundated catacombs.

While debating as to which current might be the main stream, the solemn silence was broken by a strange noise, like the cough or bark of some underground monster. Stephenson fired his revolver with a crash and resultant echoes, enough to frighten any ordinary enemy into fits. But the ominous barking only grew louder than before. Resolutely he sought and found the cause, which was a small orifice just above water level, into which the motion of the boat forced successive wavelets with the result described. In trying to catch some eyeless fish one of his lamps was put out, his matches were wet, and his boat was nearly capsized, which might have been fatal. Accordingly he made his way out, after first carving his name on the wall as a token of his farthest advance. On this trip he was gone for three hours from the time of embarkation.

The next day, on his second voyage, he took Nick on board, with as many lamps as they could carry, and a lot of matches in a bottle. The two men were too heavy for so small a boat, and Nick was landed on the broad island, with a couple of lamps, while Stephenson went on by himself. After passing the record of his first day's trip, he proceeded without special incident till he found the passage obstructed by fallen rocks. He then landed and went for a long distance on foot, when he again reached open and deep water. By this time he was so exhausted that he resisted the impulse to try to drag his boat over the rocks and launch her again. It took an hour and a half to get back to the island where Nick had been left, and the whole trip took four hours. The two trips consumed seven hours in all on waters no other man has ever explored, and whose source and outlet no man knows.



1. Mouth of pit. Arrow indicates direction from which water came for the waterfall. 2. Bottom of pit. The location of the monument shows the outlet of the water disappearing through the ledge. + is where the waterfall strikes the bottom. It is estimated mouth of the pit is twenty feet in diameter and the bottom about fifteen feet.

MAMMOTH CAVE—THE MAELSTROM PIT.

Stephenson claims to be the first white man that explored the Roaring River, which he reached by a passage opening at the Cascade beyond Echo River. He waded about for some time, catching eyeless fish. Then he and Nick set sail in a strange, cranky little boat, and paddled along for a mile. It is not stated if they explored what is now known as Aquarius Avenue; but they probably did so, as the long avenue into which this opens bears the explorer's name, Stephenson's Avenue, and contains Neptune's Cups and other objects of interest.

Croghan's Hall is usually spoken of as the end of the cave. On its right is a horrible pit called "The Maelstrom." Its opening yawns for 20 feet amid wet and slippery rocks. The depth was long said to be 175 feet; but as measured by the writer is only 90 feet.

In 1859 William C. Prentice, of Louisville, rigged a set of pulleys, and by means of a stout rope and basket descended this pit. The story was published at the time in the Kentucky papers, and was done into spirited verse by George Lansing Taylor. The story was highly embellished, but the main fact was verified to me by witnesses.

During Mr. Proctor's management, as he himself told me, a man named Babbitt was successfully lowered to the bottom of the Maelstrom by the guides Matt and William. He is said to have found a side opening, through which he essayed to go, but found the water too deep to be forded. William told me that the guides did not lose sight of Babbitt's light at any time. The date of this descent I do not know.

Mr. F. J. Stephenson claims to have made the descent four years after it was made by Prentice, and in the presence of thirty persons; namely, Nicholas Brandsford, Frank de Mowbrand, two other guides, five of Owsley's slaves, a visitor from Boston, and a number of officers and soldiers. The slaves cut and carried a stout pole and a new rope, which they lashed firmly to stalagmites, so that the middle of the pole overhung the pit, and the rope fell clear of the sides. Two loops were made for the legs, and a hitch was taken around the waist, leaving the hands free. With two lamps in one hand and a stout stick in the other, Stephenson started down, while De Mowbrand and the stout negroes held and paid out the rope. To the explorer's surprise, he found that the floor of the hall where the party stood was a thin crust. The torsion was distressing till he landed on a ledge forty feet below, when the vertigo ceased. He was within speaking distance of the guides. After a short respite he ventured down the second or inner pit, whose walls were polished and perpendicular. He ordered the rope to be paid out slowly, and contrived to keep near the wall, thus escaping the whirling that had annoyed him. Soon he reached the bottom, drenched by the waterfall from above. The pit here was 30 feet in diameter, and the bottom covered with blocks and debris. The stones that were knocked off from above endangered him. Accordingly he crawled into a crevice, and took refuge in it, while waiting for Nick and De Mowbrand to descend. On the floor of this side avenue were curious black stones and fragments of alabaster, with which they filled a small basket. At the end of an avenue Stephenson wrote his name and address and the date, August, 1863. So far as known, no one has ventured down this abyss from that date till May of the present year. The managers have denied all requests for permission to descend, till a recent exception was made in favor of Mr. Benjamin F. Einbigler, of New York city.

On May 13, 1905, he and John Nelson, guide, went down a pit 60 feet deep, near Serena's Arbor, hoping to find a crevice by which to pass easily into the larger pit. But the crevice was too small for them to go through. Accordingly, on May 15, they approached the Maelstrom directly, accompanied by Ed. Hawkins and Levi Woodson, on whom they relied to hold the rope while they went down.

The accompanying diagram will show the contour and surroundings of the pit, and their method of approach. The thin shell of stalagmite, which had for forty years been regarded as an element of danger, was found to be supported underneath by an earth pocket, so that the wall did not very greatly recede during the first part of their descent. They were not much troubled by torsion. Each man was in a kind of rope basket that left him free to use both hands. The present shape of the chasm does not exactly tally with former accounts. Grave doubts are expressed as to Babbit's having ever gone down the pit at all. Prentice went down, but his story was made so romantic as to be of little use. There is no doubt that Stephenson explored the depths as described, yet certain features mentioned by him do not now exist. No black stones were found at the bottom, but only smooth water-polished limestone blocks, with fragments of so-called "onyx," and debris thrown down from above. Instead of a deep stream they found only a shallow one. The avenue in which both Prentice and Stephenson were said to have wandered so far, shrinks to a mere niche with a wide opening. Of course, the names written in the sand vanished long ago. The fact should be remembered that all these deep pits are wrought by steady and continued erosion, which, in the writer's opinion, may have caused many changes in the period of forty years, even to the extent of occluding an avenue that formerly existed. The general details of earlier visits are so circumstantial, and so well established by testimony, as not to be hastily cast aside

reason of alterations which may have been wrought by time.

The only visible drainage of the Maelstrom is through a small crevice at the bottom, into which both Stephenson and Einbigler went, in order to escape from falling rocks dislodged from above. It seems as if so large a chasm must have had at some former time a correspondingly large outlet, even though now occluded. The recent explorers found a scantling that had been thrown into the pit, and they set it upright, with massive stones piled around it. A square flat stone was fixed at the top, on which they inscribed "B. F. Einbigler, John Nelson, guide, May 15, 1905." This done, they returned to the mouth of the Maelstrom, their heroic task accomplished.

The early charts indicate two openings from the vicinity of Mary's Vineyard, one of which is Boone Avenue, and the other an avenue to the Mystic River. The latter has been sought diligently by many explorers, including myself, and sought in vain. Accordingly, we came to the conclusion that the Mystic River was a myth. But Mr. Einbigler reached it in May of this year. He went through Boone Avenue, passing around several "fall-ins," and deep pits, and then turning back through a parallel passageway till he came to the river sought. At the time of his visit the stream was about six feet wide and a foot deep, but the banks were strongly marked by signs of its having recently been much wider and deeper. Going still farther, he entered what is regarded as a newly-discovered dome of immense proportions, fully equal to anything previously found in the Mammoth Cave. In honor of his sister, who was with him at the time, he gave this magnificent room the name of the "Edna Dome." It is to be hoped that the management of the cave may soon make some of these new attractions of their wonderful cavern accessible to the general public, instead of limiting visitors so strictly to the beaten paths of the more familiar routes.

DAIMLER'S COMPOUND MOTOR.

AT its factory in Germany the Daimler Company is bringing out a compound motor of original design fitted with combined intake and exhaust valves, on which patents have recently been issued. It is a well-recognized requirement of the successful compound gas engine that the passage between the cylinders for the gas already expanded in the high pressure cylinder must be as short as possible, so that a minimum of heat will be lost before its entrance to the low pressure cylinder. But its efficient accomplishment is attended by the difficulty of burnt valves, which rapidly ensue unless some means of cooling be provided.

This has been overcome in the Daimler engine without the employment of any intermediate valves, by causing the exhaust valve of the high pressure cylinder to act as the inlet of the low pressure as well. This will be noted in the accompanying longitudinal cross section.

The cooling of the body of the valve is by means of the fresh gas, and being housed in the center of the cylinder head, is surrounded by a cooling medium best adapted to maintain the loss of heat suffered by the exhaust at a minimum. A water circulation is also maintained, not alone in the cylinder jackets, but also about the seats of the valves and the cylinder heads. Differing from the usual practice, this is not cold, but warm, water, which in evaporating serves to absorb the excess heat. It is said to be readily possible by this method, not only to maintain an exactly uniform temperature, but further to prevent the latter from dropping below a determined minimum.

In order to prevent the return of the exploded gases from the low pressure cylinder and to exclude them from mixing with the incoming fresh charge, a specially designed check is provided about the valve itself. It is in the form of an annular movable chamber surrounding the valve and depending entirely for its operation upon the reaction of the once exploded gas.

The cross section shown represents an engine of the usual design employed in gas engine compounding. It consists of the two high pressure cylinders, disposed symmetrically on each side of the low pressure cylinder, *B*.

The exhaust valve, *a*, is composed of a hollow tubular body, having as its seat the upper face of the inlet valve, *b*. By this means the exhaust valve is also caused to act as a heater of the fresh charge of fuel, and during the passage of the latter it is cooled. When the cylinder, *A*, exhausts, the valve, *a*, leaves its seat and permits the once expanded charge to pass into *B* through the passage, *c*, which, on account of the placing of the valves in the cylinder heads, is extremely short. This passage is composed partly of the cylinder, *B*, and partly of the high pressure cylinder, which provides both a seat and a guide for the valve, *a*.

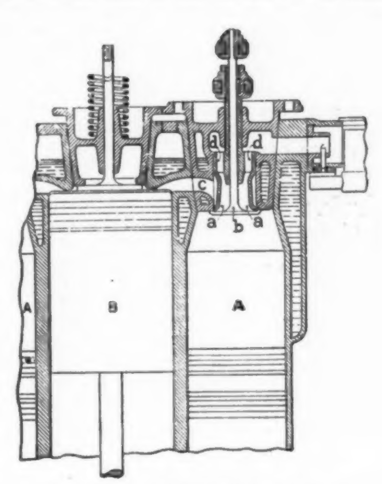
The burnt gases are thus not permitted to part with more than a negligible quantity of their heat before again expanding in the larger cylinder, and by means of the method of cooling the cylinder head shown by the sketch, all the parts are maintained at a constant normal temperature.

It will be seen that the valve, *a*, governs the admission of these gases as well as preventing their return by moving up and down, this travel being guided by *d*, which is an extension of *a* in the shape of a hollow piston. When the latter rises it engages the circular piece just above it, so that the exhausted gases are compelled to pass into the passage, *c*. The suction stroke of the high pressure piston then draws it downward again and permits of the entrance of the fresh charge. This exhaust valve is thus delicately balanced and quickly responds alternately to the action of the incoming and exhausted gases.—The Motor World.

RECENT DEVELOPMENTS IN THE APPLICATION OF LIQUID FUEL TO MARINE BOILERS.

By the English Correspondent of SCIENTIFIC AMERICAN.

INTEREST among British engineers concerned in the utilization of liquid fuel for marine boilers has been recently directed to some highly successful tests that have been carried out in England with various types of burners. The results of these trials, in view of those that were obtained a short while back by our own Admiralty board, provide interesting and comparative reading. After a series of exhaustive tests on many injector burners sent to the United States Admiralty



DAIMLER'S COMPOUND MOTOR.

for competition, two injectors were selected by the board from the group as giving the best results. Another series of tests were then made with these two injector burners. The oils used in the trials were California crude and semi-refined Texas. The heating power of the Texas crude oil varies between 19,500 and 20,690 B. T. U. Taking both figures, the lower and the higher, viz., 19,500 and 20,690, these give a theoretical (say 100 per cent) evaporation of 20.16 and 21.40 pounds of steam respectively per pound of oil calculated from and at 212 deg. F. Such figures in practice are not obtained, as so much is consumed in radiation, conduction, flue-heating, etc., which altogether amount to a considerable percentage. The results of the series of tests carried out by the board on these two injector burners average 12.29 pounds of steam respectively per pound of oil with the one and 12.08 pounds with the other, circulating from and at 212 deg. F., which may be taken to be about 60 per cent duty. Doubtless these figures are high, probably as high as an injector burner will go, but they are low in comparison with the systems in use in Great Britain. Prof. Watkinson, of

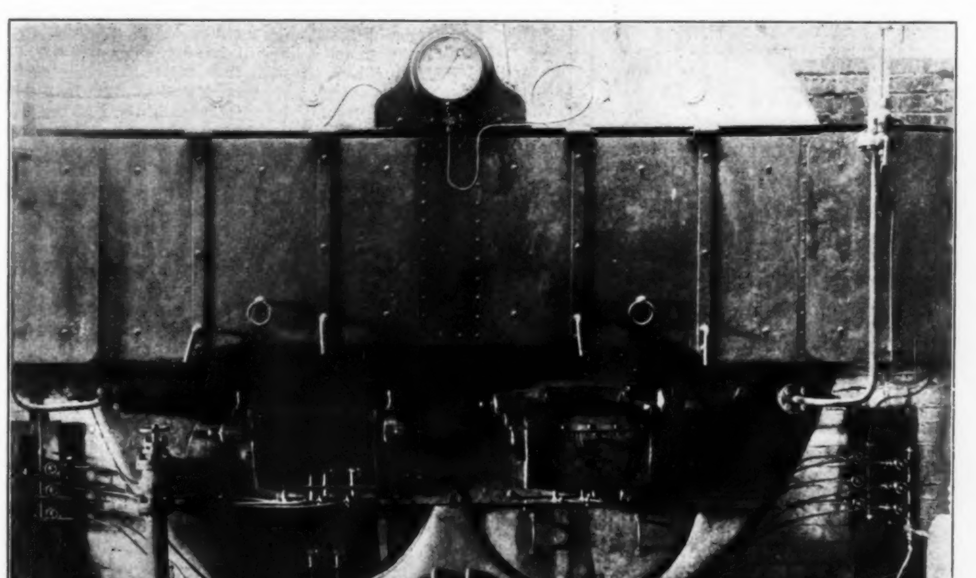
84 per cent—a point beyond which it is barely possible to go when the usual furnace allowances are taken into consideration. Thus it will be seen that with the oil used in the United States tests, giving as mentioned above 19,500 as lowest and 20,690 B. T. U. as highest, the Lucal system at 75 per cent only gives an evaporation of 15.12 and 16.05 pounds of steam per pound of oil from and at 212 deg. F., while 84 per cent gives 16.93 and 18 pounds respectively. It may also be added that while 4½ per cent of the total amount of steam formed was consumed to atomize the oil by the injectors as found by the United States board, Prof. Watkinson found that the Lucal device only took 1½ per cent.

The result of these investigations has directed attention to the Lucal apparatus, which is the outcome of seven years' patient study and experiments. The inventors of the system have especially devoted their energies toward obtaining the full duty from the oil, and to use the heat safely and as satisfactorily as coal under a boiler. With this apparatus the oil globule is broken into vapor and floating particles by highly superheated steam, before it leaves the burner head. By this arrangement complete aerification is assured. It is impossible to aerify liquid globes for burning purposes, but once the oil is brought into the condition of gas, perfect aerification can then be effected. It is similar to what occurs in a blowpipe flame, and a blowpipe flame is produced by the Lucal system. In this burner the oil (which may be supplied by gravitation) is fed into a cup, whence it flows in a fine stream to meet the steam near the mouth of the apparatus. The oil is thus kept as cool as possible until the last moment, so as not to break it up in any way. When it meets the steam, the great heat at that point vaporizes the oil, or all that will vaporize, while the unvaporizable remainder is broken into fine molecules, to burn as incandescent particles. Simultaneously, the air which has been drawn in by the action of the steam, and which is highly heated on its passage, mixes with the vapor and the unvaporable portions of the oil, the whole enters a passage in the cap of the burner, where the mixing becomes complete, and it is then ejected in this highly-prepared condition, to instantly burst into flame when lighted, without smoke, and in the best condition to do full and safe duty in the boiler.

It may be mentioned that an injector of the ordinary type is unsatisfactory for employment with superheated steam of the requisite temperature, since it becomes overheated. The heat then disintegrates the oil, deposits carbon, and the ports become charred up, rendering the apparatus useless in a few minutes.

The fundamental principle of the Lucal system is the preparation of the oil outside the furnace, so that it can work effectively inside the furnace. Further, the oil must be brought partially or wholly into a state of vapor, and be thoroughly commingled with air before it reaches the furnace, by means of highly superheated steam. The latter is formed on its passage to the ejecting nozzle.

One very prominent feature of this system is that the flame itself may be regulated from a slow, smoky flame to that of a fierce blowpipe. This is attributable to the fact that all the entrances of the oil, air, and steam respectively may be controlled to a point. For



A SYSTEM FOR BURNING LIQUID FUEL UNDER MARINE BOILERS.

Glasgow, recently carried out a series of tests with the system of the Lucal Light and Heating Company, of that city, and obtained results far in advance of those achieved by the board appointed by our own Admiralty. Prof. Watkinson's results showed that combustion was practically perfect, and that an effective evaporation of 75 per cent was obtained by the Lucal apparatus, and with a little careful working it ran up to

steam-raising purposes the device is fixed to give a flame similar to that of coal in perfect combustion. Extensive lining of the furnaces with brickwork, as is necessary in other systems, in order to protect the boiler plates is thereby dispensed with, and full and free play is secured for the radiant and for the contact heat of the flame.

The steam is drawn from the boiler for injection,

and works effectively from 30 pounds upward. It is passed through the burner, and is thus highly superheated in such a way that overheating of the burner is avoided. Any class of oil may be employed, either burning, crude, or refined. It is not necessary to prepare the oil in any way beyond drawing away any water that may have collected in the tank. Should it be too thick to flow easily, it is slightly heated before use.

To raise the pressure in the boiler from the cold, sufficiently to work the system, a separate starter is used, and dispensed with when the necessary pressure has been obtained in the boiler. This starter comprises a burner head and a tank of water, with means to put it under a pressure of 60 pounds. The water is conveyed to the starter with a piece head, which has already been coupled to the oil pipe. The coils of the starter head are heated with a piece of oily waste to begin, and when sufficiently hot, the water is turned on, and then the oil. As the water runs through the coils it is instantly converted into steam, and thus supplies the steam necessary for ejection. After starting the apparatus, no further attention is necessary beyond seeing that the proper amount of oil is being maintained.

Some interesting tests have also been carried out with another system—the Korting—by the Wallsend Slipway and Engineering Company, Ltd. (England). This principle differs from all other methods in that the fuel is sprayed directly into the furnace simply by forcing it through a Korting sprayer by means of a pump. By this process a steam jet is dispensed with, and the consequent result and advantage are that no additional evaporative plant is necessary. Before reaching the burner the oil fuel is carefully filtered, and heated to a temperature which depends upon the quantity of oil to be burned.

A demonstration of this system was recently carried out before a number of marine engineers interested in the application of liquid fuel to vessels, and also before a number of members of the British Admiralty Committee on Liquid Fuel.

For the purposes of this experiment, a boiler of the ordinary marine type designed for forced draft was used. The dimensions of the boiler were 12 feet 6 inches diameter by 11 feet long, with two large furnaces 3 feet 7 inches in diameter. There were 262 tubes, each $2\frac{1}{2}$ inches diameter, and fitted with retarders. The boiler was completely inclosed in an air-tight house, so as to show the system working under both natural and forced draft conditions. The total heating surface was 1.695 square feet, with 40 square feet of grate area under coal and a working pressure of 120 pounds per square inch. For the natural test the doors were left open. The stokehold was then closed and the fan started, when it was shown that the system may be worked with almost any degree of air pressure; $4\frac{1}{2}$ inches was ultimately recorded on the gage. Throughout the trial there was an absence of smoke at the chimney. The results of the test were as follows:

	Coal Trial	Natural Draft	Closed Stokehold
			Air pressure $1\frac{1}{8}$ in.
Duration of trial	6 hours	5 hours	4 hours
Class of fuel	Best Mickley picked	Texas oil	Texas oil
Average steam pressure	113 lb.	115 lb.	1'5 lb.
" temperature of feed-water	55 deg. F.	80 deg. F.	107 deg. F.
Pressure of oil at burners	....	75 lb.	140 lb.
Temperature of oil at burners	....	240 deg. F.	110 deg. F.
Quantity of water evaporated per hour	7558 lb.	7756 lb.	14,951 lb.
Quantity of oil burned per hour	....	633.4 lb.	1222 lb.
Quantity of coal burned per hour	974 3 lb.		
Water evaporated per pound of oil (actual)	....	12.24 lb.	12 23 lb.
Water evaporated per pound of coal	7.76 lb.		
Water evaporated per pound of oil from and at 212 deg. F.	...	14.45 lb.	14.06 lb.
Water evaporated per pound of coal from and at 212 deg. F.	9.31 lb.		
Equivalent quantity of water evaporated per hour from and at 212 deg. F.	9060 lb.	9152 lb.	17 193 lb.
Total quantity of ash	283 lb.		

An evaporative test was also carried out, and an evaporation of over 16 pounds of water from and at 212 deg. F. was obtained per pound of oil fuel consumed.

EFFECT UPON HEALTH OF VARYING AMOUNTS OF BORAX.

The most interesting of the observations which were made during the progress of Dr. Wiley's borax experiments was in the study of the direct effect upon health of boric acid and borax when administered in food. When boric acid or its equivalent in borax is taken with the food in small quantities, not exceeding half a gram ($7\frac{1}{2}$ grains) a day, no notable effects are immediately produced. The medical symptoms of the cases in long-continued exhibitions of small doses, or in large doses extending over a shorter period, show in many instances a manifest tendency to diminish the appetite and to produce a feeling of fullness and uneasiness in the stomach, which in some cases results in nausea, with a very general tendency to produce a sense of fullness in the head, which is often manifested as a dull and persistent headache. In addition to the uneasiness produced in the region of the stomach, there appear in some instances sharp and well-located pains which, however, are not persistent. Although the depression in the weight of the body and some of the other symptoms produced persist in the after periods, there is a uniform tendency manifested after the withdrawal of the preservative toward a recovery from the unpleasant sensations in the stomach and head above mentioned.

The administration of boric acid to the amount of 4 or 5 grammes per day, or borax equivalent thereto, continued for some time, results in most cases in loss of appetite and inability to perform work of any kind. In many cases the person becomes ill and unfit for duty. The administration of 3 grammes per day produced in many cases the same symptoms, although it appeared that a majority of the men under observation were able to take 3 grammes a day for a somewhat protracted period and still perform their duties. They commonly felt injurious effects from the dose, however, and it is certain that the normal man could not long continue to receive 3 grammes per day.

In many cases the same results, though less marked, follow the administration of borax to the extent of 2 grammes and even of 1 gramme per day, although in some of the cases studied the illness following the administration of borax and boric acid in those proportions may be explained by other causes, chiefly la grippe.

The administration of borax and boric acid to the extent of one-half gramme per day yielded results markedly different from those obtained with larger quantities of the preservatives. This experiment, conducted as it was for a period of fifty days, was a rather severe test, and it appeared that in some instances a somewhat unfavorable result attended its use. On the whole the results show that one-half gramme per day is too much for the normal man to receive regularly. On the other hand, it is evident that the normal man can receive one-half gramme per day of boric acid, or of borax expressed in terms of boric acid, for a limited period of time without much danger of impairment of health.

It is, of course, not to be denied that both borax and boric acid are recognized as valuable remedies in medicine. There are certain diseases in which these remedies are regularly prescribed, both for internal and external use. The value which they possess in these cases does not seem to have any relation to their use in the healthy organism except when properly prescribed as prophylactics. The fact that any remedy is useful in disease does not appear to logically warrant its use at any other time.

It appears, therefore, that both boric acid and borax, when continuously administered in small doses for a long period or when given in large quantities for a short period, create disturbances of appetite, of digestion, and of health.

HOW A BIG HOTEL IS MANAGED.*

The successful hotel manager, like the poet, must be born, not made; but, like the engineer, he must learn his business from the beginning—if not by "going through the shops," at least by years of hard work at the outset of his career. Natural aptitude for the business is invaluable, and even essential, to complete conquest of the many details of hotel management; but in addition to this, the youngster who is ambitious of reaching the top of the profession must start by learning how everything is done. To this end he should seek an appointment as manager's clerk. In this capacity he will have the opportunity of acquainting himself with the duties of all the staff and the idiosyncrasies of visitors, and in time may hope to assume full control and responsibility. Merit is fully recognized, for the page-boy who shows himself capable may rise to appointments of dignity and importance; but the manager's clerk is given from the outset an insight into the way in which things are done. He must, moreover, be smartly dressed and well-mannered, and at the same time he must be able to command the respect and ready obedience of the staff; otherwise, with the best will in the world, he runs the risk of failure.

One of the most important of the daily duties of the manager's clerk is the marketing and ordering of supplies of all sorts for the kitchen and housekeeping departments. A London manager will probably be instructed to be in Covent Garden Market by six o'clock in the morning to look over the pick of the fruit and vegetables. Other foodstuffs may be obtained from the daily price-lists sent in by the leading firms. From a comparison of these the manager makes his selection; and his clerk, whose duty it is to write out the orders for signature by his superior, is thus able to pick up an all-round knowledge of what to get and where to get it, what is in season, and how to drive the most advantageous bargains for the supply of food in large quantities. These orders are based upon the requisitions sent in every morning by the *chef* for the following day. He may, for instance, ask for fifty chickens, a hundred quails, and so forth; and the manager, running his eye down the poulterers' lists that lie before him, marks the items required from each, and his clerk then makes up the order-book accordingly, which, when all the requirements of the various departments have been dealt with, is signed by the manager, no other signature being recognized as valid in this connection. It will be seen from this that the manager's clerk who knows how to use his opportunities will soon begin to be acquainted with the ordinary details of hotel-supply; and as the range of things required is very wide, his knowledge of prices will become very considerable. The whole responsibility of buying rests with the manager, who must therefore be above suspicion of trickery. The *chef*, for example, is not allowed to know the names of the firms which are to supply him on the following day with his materials; and, similarly, the head housekeeper is not tempted to favor any particular firm that may wish to get into her good graces.

Equally important in its way is the daily inspection of the rooms, for which the manager's clerk is responsible. It is his duty to go round and note instantly any sign of carelessness or neglect on the part of the servants. Every detail in each room must be swiftly, but exactly, examined, so that visitors may have little or nothing with which, even in their most unreasonable moments, fault can be found. Any article left behind by a visitor, and unreported, will, if discovered by the quick eye of the clerk, bring reprimand or dismissal to the offending servant; while small repairs must be noted down for immediate attention, and dirty windows or dull mirrors must not be allowed to pass unnoticed. Constant practice at this sort of inspection develops in the future manager an extraordinary and almost abnormal quickness of eye, so that on entering a room he can detect at a glance the slightest sign that the housemaids or the waiters have done their duty carelessly, or that there is a job for the carpenter or upholsterer. This faculty is noticeable in all who have so worked their way up to the responsible position of manager, to whom it is as useful and necessary as to the subordinate inspecting officials.

Accounts are kept by a special staff; but here, too, the manager takes the final responsibility. It is also his duty to prepare, from the reports submitted by the various branches, the quarterly balance-sheet, which is, of course, kept private, and known only to himself and his directors. He must, therefore, add to all his other qualifications a comprehensive grasp of figures and a sure appreciation of his position as far as profit-earning is concerned.

The smooth working of a big hotel, like that of a ship, depends largely upon the personality of the man in charge, who must be able to command the respect and ready obedience of a hundred or perhaps two hundred subordinates. It is not sufficient that he should be acquainted with all the details of administration, for a man may have a perfect knowledge of these and yet fail to keep adequate control. His knowledge of human nature in all its varieties must also be extensive, and his long training as manager's clerk will have done much to give him this necessary experience. The endless succession of visitors will afford him hourly opportunities for the display of that tact which knows how to conciliate and when to be firm. As a hotel depends for existence upon the satisfaction which it can give to those who use it, a special book is kept in each department, in which every complaint, trivial or well founded, is entered. These books are submitted every day to the manager, who, if he knows his business, will investigate each case personally, with a view to setting matters right. In almost every instance, too, the visitor who makes the complaint is politely asked to call at the manager's office. At the interview the manager expresses his regret that any cause for complaint should have arisen, and asks for fuller information. Sometimes the visitor may express surprise that his lightly-uttered remark has been brought to the attention of the manager; but whether the complaint was really well founded or not, the result is to impress the visitor with the fact that the manager's control is effective, and designed to minister to his comfort. This is as it should be, for the manager who means to bring visitors back again and again must make them feel certain that their personal well-being during their stay under his roof is his personal concern. They may, for the sake of convenience, be labeled with the number of the bedroom which they occupy; but to the manager they are not mere ciphers, but men and women to be humored, even sometimes to the extent of breaking the recognized rules of the hotel. At the same time there are limits to the manager's forbearance, and the visitor who transgresses these will be politely but firmly informed that his bedroom will be required by noon of the following day. The manager, of course, must also have an exact knowledge of the law as far as it applies to hotels, and the practice of noting all precedents as they occur will help in deciding doubtful cases of liability or other claims. As hotels must receive all comers, it is not always possible to avoid harboring now and again some disreputable members of society. But a "black list" of suspicious visitors is kept, and even if any of these escape the vigilance of the manager and secure admission, they are soon quietly told to find quarters elsewhere. In such cases an informal but strict watch is kept on what goes on, and notice to quit is given on the first opportunity. Some hotels, of course, have a higher reputation than others in this respect; but no precautions can absolutely secure even the best-managed hotel from the temporary intrusion of "undesirables."

Lastly, the manager's clerk should gain as much knowledge as possible of the making up of *menus*, and colloquial French is also extremely useful. Stock-taking will teach him something about vintage-years and the various qualities of cigars; and by the time that he becomes manager he should be able to discuss intelligently with any visitor the *menu* for a proposed dinner and the wines that are to accompany it. Various other qualities go to the making of the ideal hotel manager; but those above mentioned are at any rate among the most important. In short, he must be tactful, a first-rate organizer, with a thorough knowledge

* Chambers's Journal.

of his many responsible duties, and he must control his temper. Such a wide range of gifts and acquirements does not fall to the lot of many; and the man who can run a big modern hotel without unnecessary friction may accept his considerable salary with the feeling that he has earned it down to the very last penny.

ELECTRICAL NOTES.

The storage problem which has been insufficiently developed, but to which much attention is now being directed, is that of portable storage. We require a box of power, as it was first termed by Lord Kelvin when the Faure accumulator was brought over to this country. Lord Kelvin was not alone in thinking that we had already within our reach the power of storing considerable amounts of power in boxes of reasonable size and weight, which could be transported from the point at which they were charged to the point at which the power was to be utilized. After long years of disappointing delay we do see this realized in the very considerable number of private carriages driven by electrical means which we now see in the streets.

The development of the tantalum lamp has been a striking instance of the way a problem of this kind ought to be attacked. The search for a suitable wire was set about in a thoroughly systematic manner. Tantalum was tried as it was one of a group of metals that from their known atomic values would be likely to give the desired results. It was then hardly known in its metallic form, so that during the search it was necessary to devise means for obtaining it in sufficient quantity, to draw and toughen the wire and to mount it in a suitable manner. The result has been a lamp which, although not perfect, does yield many of the results that were expected from it, and the inquiry will very probably lead to notable additions to our knowledge of this part of the lighting problem.

The problems of the further utilization of electrical energy for the purposes of our daily life are of extreme interest. The first strong impetus given to the discovery of improved means of generating electricity arose from the desire for electric light. First came the arc light, followed by the incandescent lamp, and both have been perfected up to a certain point. By the invention of the inclosed arc we have greatly reduced the cost of labor of recarboning our lamps, and have so far increased their utility by perfecting smaller details of manufacture, and the carbon filaments of our smaller lamps have also reached better efficiency and regularity of light-giving power than was at first the case. Still, as at present produced, they fall short of what is desired in point of efficiency; but there is, nevertheless, room for hope and material benefit in this respect. For years past many minds have been attempting to solve the problem of obtaining increased light from an incandescent filament or wire. The successive appearance of the Nernst, the Auer, Von Welsbach, the Osmium, and, finally, the tantalum lamp indicate the more or less successful efforts that have been made and which seem likely to yield satisfactory results.

It may surprise many to hear how great have been the improvements in the lead-couple accumulator during the fifteen years or so that it has been in practical use. These developments have been steady, continuous; but the fact remains that the accumulator, as we now have it, has taken rank as a part of our electrical plant which is well understood, and from the use of which many of us are obtaining great economical benefit. The causes of this improvement are two-fold. Our early troubles arose partly from difficulties in the manufacture of the plates in the accumulator cells; means were adopted to hasten the formation of these plates during their manufacture, for which we paid somewhat dearly by their shortened life. Another and very important cause of our early troubles was that for a long time we continued to use the cells themselves as a means of regulating our electrical pressures. This introduced conditions extremely unfavorable to the regulating cells of our batteries of accumulators, but since, owing to the discoveries of Chamen, Highfield, and others, we have obtained regulation by means of automatic motor generators, to which the name of boosters has been generally given, this difficulty has been largely removed, so that the life of a battery is no longer confined to the short life of its regulating cells, but is that of the life of the whole mass of cells that are all working under equal conditions.

Fleming has shown that in all probability the method that we have arrived at at our present stage of development to communicate waves to the ether by the oscillating discharge of condensers only extends over probably one per cent of the time available, in fact, that we only have a series of intermittent waves with long vacant spaces intervening. What we require is a better method of originating a continuous train of waves rather than these intermittent ones, and here we can formulate our problem, which may be solved by the mechanical engineer, or probably by the electro-chemical engineer. None of us have as yet succeeded in constructing an alternator with a frequency approaching 1,000,000 per second; but who can say that recent developments in extremely high-speed turbo-generators of the De Laval type may not furnish us with a good start in obtaining such frequency by mechanical means. Again, turning to the possibilities within reach of the electro-chemist, very promising attempts have already been made by Lodge and others to produce electrical oscillations from condensers charged by a Cooper Hewitt mercury vapor lamp. Duddell has shown by his investigation of the singing arc that herein lies a method of producing a continuous series of discharges, although in this case the frequency obtained is not sufficient for our purpose. At any rate, the solution of this problem of continuous operation by means of Hertzian waves appears to be extremely hopeful, and at any rate it is one of first importance.

ENGINEERING NOTES.

There is increasing interest in the formulation of courses in rural engineering and the provision of special facilities for instruction in this important subject. Special attention is being given to instruction relating to the construction and use of farm machinery. The continued scarcity of farm labor in almost all of the agricultural regions in this country makes necessary the employment of farm machinery on even a more extensive scale than has hitherto prevailed. The total value of implements and machinery on farms in this country, according to the last census, was $761,261,500, an average of $133 per farm and of 90 cents per acre of farm land. Much of this machinery is elaborate and complicated in construction and requires mechanical skill for its most efficient operation and care. In very many cases it is also essential that the farmer shall understand how to repair such machinery. It represents an important part of the farmer's invested capital upon which he must earn or pay interest. That there is an enormous waste of money due to neglect and unskillful handling of this part of the farm equipment must be obvious to any one who has traveled through the regions where it is most used. The colleges can therefore do a very important work in training their students so that they will understand the construction, care, and most economical use of farm machinery.

The expressions, gaseous and non-gaseous mines, are supposed to classify mines into those that are dangerous because of firedamp, and those that are not dangerous because firedamp has not been detected in them. Evidently, those in charge of non-gaseous mines are lulled into a false sense of security, as from time to time explosions occur in such mines that are as prolific in fatality, if not more so, than those explosions which occur in gaseous mines. This remark might give rise to the following pertinent questions: Are there any non-gaseous coal mines? Do non-gaseous mines suddenly become gaseous? Since methane is more or less a chemical constituent of coal, particularly bituminous coal, and since it is also occluded in coal and in rock surrounding the coal strata, it would seem to be entirely feasible to suppose that it would be found in all coal deposits. The oxidation as well as the disintegration of coal at exposed surfaces should liberate the gas, and since it exists to some extent in the inclosing coal strata, excavations made in coal beds should also set it at liberty. The nearer the coal bed is to the surface, the more opportunity there is for the gas to escape from crevices and rock fissures. Nevertheless, it is not probable that all gas has escaped in this way. It seems possible that a non-gaseous mine might suddenly be converted into a gaseous mine, either by gas blowers and by breaking the strata that previously dammed back the gas or by converting coal dust into gas. A combination of coal dust and firedamp makes about the most deadly natural explosive mixture that is met with in mines, because one intensifies the effects of the other. Gas, as is well known, will not explode unless there is sufficient air mixed with it to furnish oxygen for combustion, and coal dust will not ignite except under similar conditions. Where there is twenty times as much air as gas, no explosion will occur, although combustion readily takes place. It is easy to conceive of a condition where there is enough gas present locally to ignite fine dust and the flame produced by the combustion converting the coal in the dust into marsh gas, carbon dioxide, and coke. The two gases formed are explosive and are generated so rapidly as to form an explosive mixture of gas with the remaining air of the mine. At the conclusion of a lecture in Wilkesbarre before a representative body of superintendents, mine foremen, and fire bosses, this question was asked: Can you explain why gas explosions are more fatal in bituminous mines than in anthracite mines? The subject was new to them, as several asked if that were a fact. Assured that it was, some thought that the ventilation was not as good in the bituminous districts as in the anthracite districts, and others presumed that the afterdamp was more fatal, but to the writer neither one surmise appeals since there is more gas in the anthracite mines and there are more explosions, yet the explosions are local in character and any gas explosion is due to lack of ventilation. Besides, in the so-called gaseous mines in the bituminous fields of Pennsylvania the fire bosses and fans are as active as in the Pennsylvania anthracite field and the inspectors are as well versed in their line as are those in other fields. In 1903, twenty-six were killed and 181 injured by gas explosions in the anthracite mines. In the same year 23 were killed and 23 injured by gaseous explosions in the bituminous mines. The percentage of fatality from these explosions in the anthracite mines is 12.56, while the percentage of fatality from explosions in the bituminous mines was 50. The evident cause of the increased fatality in one class of mines is coal dust. There is dust in the anthracite mines, but not nearly as fine nor as explosive as in the bituminous mines. The small quantity of volatile matter and the high degree of heat necessary to fire anthracite prevents the ignition of anthracite dust by explosive mixtures of gas. Volatile hydrocarbons in bituminous coal are readily liberated by heat and these gases will ignite and so intensify the heat that larger quantities of gas will be produced from the dust. The fixed carbon will be rendered incandescent and assist the gas in injuring the unfortunate by increasing the intensity of the heat. The incomplete combustion that occurs in gas and dust mixtures produces carbon monoxide that will cause death to those injured or rendered unconscious by the explosion. Carbon monoxide of incomplete combustion composes the afterdamp to a larger extent in bituminous than in anthracite mines, and this no doubt is an additional reason why fatality is greater.—Mines and Minerals.

TRADE NOTES AND RECIPES.

Clear Polish.—Dissolve stick lac 25 parts, shellac 20 parts, and gum benzoin 4 parts, all finely powdered, in a rolling-cask containing 100 parts of 96 per cent alcohol; perfume with 1 part of oil of rosemary. Upon letting stand for several days filter the solution, whereupon a good glossy polish for leather, etc., will be obtained.—Seifensieder Zeitung.

Liquid Dextrin Glue.—Dissolve by heating 60 parts of borax in 420 parts of water, add 480 parts dextrin (pale yellow) and 50 parts of glucose and heat carefully with continued stirring, to complete solution; replace the evaporated water, and pour through flannel.

The glue made in this way remains clear quite a long time, and possesses great adhesive power; it also dries very quickly, but upon careless and extended heating above 90 deg. C. it is apt to turn brown and brittle.—Neueste Erfahrungen.

Gold Varnish for Tin.—English gold varnish is not fast to light, nor very fiery in tone. A perfectly light-resisting and very handsome gold varnish for tin is obtained in the following manner: Spread out 50 grammes of finely powdered crystallized copper acetate in a warm spot, leaving it lie for some time; then grind the powder, which will have acquired a light brown shade, with oil of turpentine and add, with stirring, 150 grammes of fat copal varnish heated to 70 deg. C. When the copper acetate has dissolved (in about one-quarter hour) the mass is filled in a bottle and allowed to stand warm, for several days, shaking frequently. The gold varnish is then ready for use. Coat the articles uniformly with it, and heat in a drying chamber, whereupon, according to the degree of temperature, varying colorations are obtained, changing from green to yellow, golden yellow, orange to brown. When good copal varnish is employed, the varnish will adhere very firmly, so that the article can be pressed without taking harm.—Bayerisches Industrie und Gewerbe-Blatt.

To Remove Rust from Instruments.—For the removal of rust from instruments, Kraft und Licht gives the following process: Lay the instruments over night in a saturated solution of stannous chloride; the rust spots will disappear through reduction. Upon withdrawal from the solution the instruments are rinsed off with water, placed in hot soda-soap solution, and dried. Cleaning with absolute alcohol and polishing chalk may also follow.

Another simple method of protecting steel instruments, needles, etc., from rust is greasing with paraffine oil. It being laborious, however, to grease complicated instruments or sewing needles properly and effectively, and as, moreover, too much oil is apt to be put on, which is difficult to remove before use, the following way is the best: Make a solution of 1 part of paraffine oil in 200 parts of benzine or carbon tetrachloride, and dip the instruments, which have been dried by leaving them in heated air, in this, moving their parts, if movable, like with forceps and scissors, about under the liquid, so that it may enter all the crevices. Next lay the instruments on a plate in a dry room, so that the benzine can evaporate. Sewing needles are simply thrown in the paraffine solution, and taken out with tongs or tweezers, after which they are allowed to dry on a plate.

Production of Copper Patina.—A very handsome green patina, which must be applied quickly, is obtained by means of a solution of cooking salt 3.7 grammes, ammonia 7.5 grammes, good wine vinegar ½ liter, sal-ammoniac 3.7 grammes. The solution should be painted on several times until the desired tone is reached.

A yellowish green patina is produced by brushing on the following liquids, leaving dry quietly: Dilute acetic acid (about 30 per cent) 250 grammes, oxalic acid 2.5 grammes, sal-ammoniac 5 grammes; or else a compound of sorrel salt (acid oxalate of potassium) 2 grammes, sal-ammoniac 8 to 8.5 grammes, vinegar (6 per cent) 500 grammes.

If the foregoing solutions are desired to present more of a bluish green shade, apply, after the above-mentioned process, a solution of sal-ammoniac 20 grammes, water ½ liter, and ammonium carbonate 60 grammes, using a brush.

A greenish brown coloring will result from a mixture of potassium sulphide 2.5 grammes, which is dissolved in ½ liter of water, and after the painting of the article allowed to dry on it. Next paint with 10 grammes of spirit of sal-ammoniac to which acetic acid is added until saturated and 5 grammes of sal-ammoniac, both together diluted with water to make 1 liter. Then dry and brush off.

A bluish-green patina is brought about by heating the following solutions: Sublimate 2.5 grammes, saltpeter 8.6 grammes, borax 5.6 grammes, zinc oxide 11.3 grammes, copper acetate 22 to 22.5 grammes. This is specially a Parisian process.

The following composition will cause a brown patina: Sorrel salt (acid oxalate of potassium) 3 grammes, sal-ammoniac 15 grammes, distilled water 280 grammes. The object has to be coated repeatedly with this solution, but the process requires a little more time.—Journal der Goldschmiede Kunst.

SCIENCE NOTES.

As a result of his study in the college, the young agriculturist must understand and be able to make use of the general principles of physics, chemistry, and geology, with special reference to soils, meteorology, and general biology. He must learn the reasons for the technical agricultural processes, and be able intelligently to modify and vary these processes to meet varying conditions; he must be able to understand and make use of improved methods in agricultural technology; in short, he has to learn how to produce by the best and most economical methods.

Our power to modify plants according to our needs has been very greatly increased and perfected by the development of plant physiology; and the working out of the nutritive requirements of plants has enabled us to maintain and increase the fertility of soils, to increase the yield and quality of crops, to prevent waste of valuable food elements, and to set to work and to improve nature's machinery for the accumulation of nitrogen from the atmosphere in combinations available to crops. We have also been able to discover the causes and find remedies for many of the most destructive diseases of crops. The result of all this in the last ten or fifteen years has been to enable the progressive farmer to protect and control his crops to a degree never before believed possible, and scientific farming is now fast becoming one of the safest forms of investment of capital and labor.

Without adequate fire protection the practice of forestry on private timber lands will not give the desired results. The leaving of seed trees, and application of modified lumbering methods for the purpose of securing natural reproduction, which is liable to ultimate destruction by fire, appeals neither to the lumberman nor to the forester. Even assuming a recognized market value for young growth, there can be little incentive for encouraging or holding it as long as a constant fire menace remains; hence it follows that fire protection is a fundamental necessity in all plans for forest management on private holdings. Definite plans for fire protection should precede or accompany all working plans for forest lands, and in most cases fire plans alone will give results which will fully justify their application.

The general attitude of lumbermen toward forest fires is one of hopelessness, coupled in a measure with indifference. Fires were not unknown prior to the days of settlement, but since the commercial exploitation of the forests began they have increased in number and severity, until now they are regarded as inevitable. Considering the many causes from which forest fires spring, the difficulty of quickly locating and suppressing them in the incipient stages, and the tremendous and often impossible task of stopping a fire when it has attained full headway, it is not to be wondered at that the lumberman has taken rather a hopeless view of the matter. Furthermore, fire fighting and even crude measures of protection require an outlay which could not have been borne during the earlier lumbering period. There has been, too, an unfulfilled State duty which has added to the lumberman's burden. Large sums raised by taxes on forest land have been going into the State treasuries, yet until very recent years no intelligent effort has been made to assist timber owners to protect their holdings. While lumbermen should have done more for themselves, the laws which should have given them encouragement and assistance have been wanting or totally inadequate.

Some epochs are now passing—as the fertilizer epoch based on agricultural chemistry. The larger question of self-sustaining farm management is now pressing. Three categories of technical farm subjects are just now beginning to demand much thought: (1) problems of feeding to increase efficiency of farm animals; (2) problems of breeding of animals and plants for the same purpose; (3) problems of the business organization of the farm, or the development of a farm-plan. We are beginning to apply research to large fundamental questions. The earlier subjects of investigation in the agricultural experiment stations were mostly the smaller and incidental ones. Now the fundamental or backbone crops and products are being investigated in their entirety—the corn crop, the cotton crop, the grass crop, the milk product, the beef product. The experiment stations are originating a kind of constructive investigational method, and the really great questions are ahead of us. Large problems come last.

The problems of agriculture are of pressing importance, both to agriculture itself and to the public welfare. They are of two kinds: (1) the technical problems of the business, (2) the problems of adjustment to the affairs of our growing civilization. The problems of adjustment are of the greatest public concern, because agriculture is our greatest occupation. Agriculture is necessary to civilization. Of all occupations, it employs most men, most capital, and is followed in the most places. It probably must always employ from one-fifth to one-fourth of the people of any self-sustaining nation. There are supernumerary, eleemosynary, and parasitic occupations; but agriculture is basic. Other occupations have had their day in the public appreciation. All of them have been born out of agriculture. Tubal-Cain was the descendant of Adam. The greatest of public problems are to come with the rise of the agricultural peoples. Just because it is basic, agriculture has been conservative and patient. Fundamental strata are likely to be azoic; but in great world-movements they are also likely to rise permanently to the top.

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